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EDITORIAL

This issue comes at a time when the COVID-19 pandemic, contrary to expectations, is surging again with rising number of new cases across the world. India has been particularly hard hit with a sharp rise in daily new cases reaching record levels, overwhelming the health care system. The crisis has been marked by a shortage of beds, oxygen, and medicines, prompting many countries to send supplies. The plans for an ambitious rollout of vaccines for adults above 18 have run into bottlenecks due to a lack of vaccine supply and distribution. These are formidable challenges to be overcome.

This situation has developed despite major global efforts at containing and reducing the spread. Scientific challenges arise due to the mutations in the virus and their impact on the immunity of humans. Restrictions on social interactions, exhortations for responsible behaviour, vaccinations, etc., have not yet succeeded, and may need to be reassessed and stepped up. Access to vaccines remains problematic compounded by a tendency for the economically strong to capture the doses. However, economic recovery is looking more promising and offers the hope that jobs and incomes will pick up.

The issue of pandemic control and the future of WHO and international health collaboration remains intensely debated, including a possible new approach based on an international treaty on pandemic control. There is a perception that in the early stage of the pandemic, there were many gaps in information sharing and that stronger measures will be needed in future. A consensus on the need for a 'One Health' approach and on ensuring equitable access to health may hopefully emerge into something concrete in future. All this shows the importance of health diplomacy, especially for optimal use of capabilities of all countries through more effective sharing of scientific research and health capability such as vaccines. The pandemic may have indeed taught humanity some valuable lessons.

Science, Technology and Innovation cooperation across countries is facing several challenges, including the tensions between the US and China over technology issues, the militarisation of outer space and cyberspace, disruptive technologies such as AI, the vast efforts required to combat climate change and to achieve the sustainable development goals by 2030. These are only a few of the challenges on the horizon. Tackling these will require science diplomacy efforts on a much greater scale. The focus cannot be simply on narrowly defined catchy slogans and goals such as "net zero emissions by 2050" but must go to the fundamental causes and roots of the challenges, with concrete milestones and measurement of progress.

During the year-long COVID-19 pandemic, people, institutions and governments have resorted to online working, including the widespread use of webinars, and work from home systems. This has proved to be cost and resource-effective, productive, and generated better participation. UN conferences, including large meetings, have taken place with good arrangements for discussions and voting on decisions and resolutions. A new phase of digital diplomacy is emerging which permits interactions between high-level leaders to take place much more easily. Web-based platforms have improved and become familiar to people. Much of this may remain with us even after the pandemic ebbs. Science diplomacy in its online avatar has come into being. However, quality and speed of internet connectivity remain a problem in many countries.

In this issue, we present articles covering a wide variety of topics related to science diplomacy. Maria Rentetzi covers the history of nuclear diplomacy and efforts to promote the use of atomic energy while reducing the potential of nuclear weapons. This is a timely article given the forthcoming NPT Review conference in 2021 and the entry into force of the Treaty for the Prohibition of Nuclear Weapons (TPNW). The article by Trithesh Nandan analyses the transmission of COVID-19 infections and enumerates ten commandments for the post-COVID world. The third article by Meyer et. al. surveys the European experience in training in science diplomacy and discusses possibilities for further widening and deepening the New Generation of Trainings on Science Diplomacy for Global Challenges.

In the perspective section, Zane Sime's explores the circulation of scientific ideas. The potential of India's new Science, Technology and Innovation Policy 2020 is analysed by Basir Ahmed, with a focus on a more effective role in shaping multilateral norms and standards. Archana Sharma's perspective explores India's scientific heritage and the future of mega-science diplomacy. We are also re-publishing the article, "Science Diplomacy and Politics" by Late Prof. M. Anandakrishnan, formerly Professor of Engineering at IIT Kanpur and India's first Science Counsellor at Indian Embassy in Washington DC. The issue includes a report review that covers the UNCTAD report on technology and innovation.

This issue presents Elke Dall and Mitchell Young's event report titled *Using Future Scenarios of Science Diplomacy for Addressing Global Challenges. In the institutions*' section, the issue reviews the Third World Academy of Sciences (TWAS) and the Aryabhatta Research Institute of Observational Sciences (ARIES). The webinar report on India Taiwan S&T cooperation held recently is also included. Under the events section, reviews of several recent events are presented, including the Global Young Academy (GYA) workshop, the India International Science Fair (IISF) 2020 and Using Science Diplomacy for tackling Global Challenges (S4D4C)'s Final Networking Meeting.

We thank our readers, authors, and stakeholders for their interest and support which is critical for further developing your journal Science Diplomacy Review into a global platform for the exchange of search, ideas, and experiences in the fast-growing world of science diplomacy.

ARTICLE

From Securing the State to Safeguarding the Atom: The Relevance of History to Nuclear Diplomacy

Maria Rentetzi*

Maria Rentetzi

The humanitarian and financial crisis that strongly hit Europe a couple of years ago forced the European Commission to assume a more political role for itself and triggered a heated debate on the need for a common foreign policy on issues such as migration and terrorism. If one forgets for a moment the COVID-19 pandemic that has overwhelmed our lives, one realizes that Europe still faces unprecedented security threats including terrorism, lack of energy connectivity, and the proliferation of weapons of mass destruction. Traditional forms of diplomacy such as preventive and economic diplomacy along with more systematic engagement in international conflicts have been pointed to as preferred actions. It is indicative that concerning the Iran nuclear deal a few years ago, the EU tried to play a key role by encouraging the United States to maintain its commitment considering, in case of withdrawal, the implications for the security not only of the United States but also of the entire region.[1] In a more recent attempt to save the 2015 nuclear deal with Iran, the EU is once again trying to revive the multilateral talks and bring the major players back to the negotiations table.[2]

Indeed, the EU has set forward the development of scientific and technical cooperation as a new and more effective instrument of security. To a traditional understanding of especially nuclear diplomacy that has

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been predominantly guided by narrow state interests and arms control agreements that sought to circumscribe nuclear risks, the EU has envisioned nuclear diplomacy as a multilateral activity and an invaluable tool to advance its global standing. To achieve this goal several initiatives have been pursued, including the funding of research projects on science diplomacy in general under the EU Horizon 2020 project. Among them, the Inventing of a Shared Science Diplomacy for Europe (InsSciDE) Project, an innovative European Union-sponsored research program, was designed in 2017 to examine the history, as well as the present state of science diplomacy and, have promised to deliver stakeholder-supported strategy and policy recommendations.[3]

Unlike the common instrumental use of history by international relation scholars,[4] InsSciDE project brings history front and centre and explores its relevance in understanding current practices in science diplomacy.[5] I coordinate the project's Work Package on security, bringing in my expertise as a historian and sociologist of nuclear sciences. The concept of security has been highly contested and historically conditioned but despite differences in theoretical approaches, security remains central to our understanding of the world and our everyday lives. To comprehend the current peculiarities of nuclear security, I analyse the key role of the International Atomic Energy Agency (IAEA) - an international diplomatic organisation within the United Nations system - focusing on the notion of security. Scholars in our research team focus on the transformation of nuclear diplomacy from a bilateral to a multilateral and multinational practice. We collectively examine the shift from thinking about nuclear security within the context of a state-centred military agenda to perceiving it as a pre-condition for the development of nuclear industry on a global level.[6] Overall, we historicize the notion of science diplomacy and explore its nuances through the second half of the twentieth century.

Security and the beginnings of post-war science diplomacy

On 7th November 1957, President Dwight Eisenhower gave a speech on science and security to the nation. In that speech, he affirmed to Americans that "as of now the United States is strong." Enumerating missiles, atomic submarines, and carriers with nuclear-armed bombers, Eisenhower hoped to alleviate fears of the Soviet threat. Clearly, national security was guaranteed through arms control. The speech broadcasted by television had a theatrical touch, while Eisenhower sat next to a nose cone of an experimental missile, which had been into space and back. Americans had indeed the need to demonstrate their country's supremacy over the Soviets in all possible ways, literary through the president's words and figuratively via the exhibited missile.

Two months earlier, the USSR has launched *Sputnik*, the first artificial satellite, an event that changed the course of U.S. international affairs by empowering the role of science in Eisenhower's policy decisions. To cover the "missile gap", the president sought the advice of renowned scientists providing them with the opportunity to directly influence his foreign policy. On the day of Eisenhower's speech, James Killian was named the first science adviser to the President and

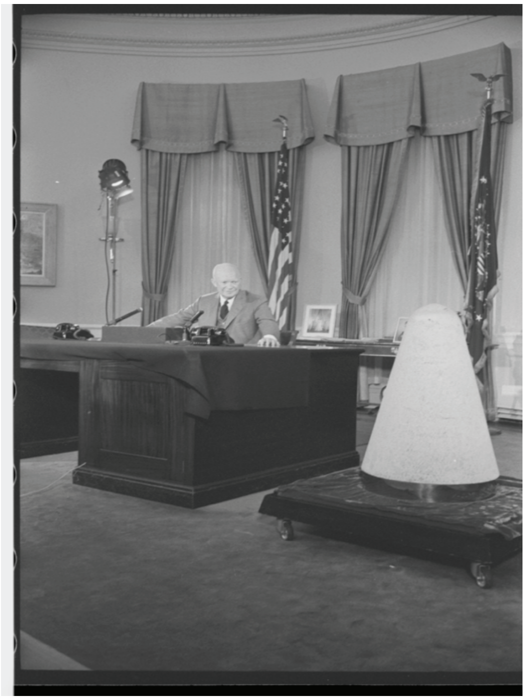

Figure 1. President Dwight Eisenhower giving a television speech in the White House about science and national security next to a nose cone of an experimental missile which had been into space and back (Courtesy of Library of Congress, control number 2012649173. Retrieved from https://www.loc.gov/item/2012649173/)

shortly after he oversaw the establishment of the President's Science Advisory Committee. If one seeks the beginnings of the institutional establishment of science diplomacy in the post-war period, Killian's entrance to the White House might be the one. As Eisenhower announced, "the very best thought and advice that the scientific community can supply, heretofore provided to me on an informal basis, is now fully organised and formalised so that no gap can occur."[7]

Killian was entrusted to offer scientific input that would ensure U.S. supremacy, keeping the country ahead in the Cold War military race. One could argue that there is indeed a subtle difference between science diplomacy as a humane activity that promotes constructive multilateral partnerships based on equality and the instrumental use of 'science' in policymaking and international affairs, as Killian was entrusted to pursue. This ideal understanding of science diplomacy, as I have argued elsewhere, is based on assumptions that science is objective and impartial, an international language that could facilitate the diplomatic dialogue.[8] Yet, scholars from academic disciplines such as the history of science and science and technology studies (STS) have long emphasised the societal and political role of science and technology that strongly shaped international relations especially during the Cold War period.[9] As an example, a day before Eisenhower's speech to the nation, Nikita Khrushchev, addressed the Soviets in a ceremony marking the 40th anniversary of the Bolshevik Revolution. Capitalising on Sputnik's launch, Khrushchev focused on Russia's economic and technical progress arguing that "this victory of the Soviet Union caused fear and perplexity" to the enemies of socialism. To him, national security could ensue from mutual disarmament and peaceful coexistence achieved by "bilateral friendly agreements in the interest of the consolidation of peace and of agreements on collective security in Europe and Asia."[10]

The security dilemma

The two talks - Eisenhower's and Khrushchev's - stood a day apart and despite their differences, they both brought front and centre the security dilemma. This means that increasing the state's military capacity forces other states to do the same. Given the ambiguity over the use of military capability for protection or conquest, the security of one state leads to the insecurity of another. In the early Cold War, the security dilemma had a direct impact on nuclear diplomacy, presupposing bilateral diplomatic negotiations. To enlist allies, the superpowers intensified the development of nuclear technologies and established programmes of technical cooperation with other nations. In short, they used gift and material-based diplomacy to manipulate negotiations and ensure support.[11] For example, 'research bilaterals' were agreements that provided American assistance in establishing research reactors and unclassified information on their design, construction and experimental operation to other nations. By December 1955, a secret progress report of the U.S. National Security Council stated that twenty-four agreements of cooperation covering research reactors had been negotiated, of which eighteenth were in effect.[12] Hence, within the context of a military agenda, security was understood mainly as the elimination of nuclear threats and science diplomacy was almost exclusively associated with bilateral negotiations on nuclear matters. By the end of 1959, the USA had concluded bilateral agreements with 42 countries to cooperate on the peaceful application of atomic energy. These agreements required concluding separate safeguards-related agreement. In the meanwhile, the United Nations charter of 1945 had already granted permanent membership to five countries, known as P5, to the UN Security Council. As a result, the United States, the United Kingdom, China, France, and Russia, all considered nuclear states, defined the postwar uneven nuclear order that left the larger part of the world in insecurity.

During the years following the war, the discussion about security was directly and emphatically linked to the nuclear arms race. The state was the main object of security and nuclear war the major threat to it. But in 1957 the special Project Committee on Security Through Arms Control of the US National Planning Association issued a policy statement that portrayed nuclear testing more as a major security risk for both the US and Russia than a national security reassurance. "On balance, we conclude that more security can be gained from a controlled prohibition of tests than from a continuation by an increasingly large number of nations."[13] In accordance with national experts' warnings and his commitment to promoting the establishment of the International Atomic Energy Agency, Eisenhower concluded his 1957 speech by stressing the peaceful uses of science as "the most important stones in any defence structure."[14]

Is science impartial?

Behind the growing interest of national governments in science diplomacy lays the use of science as an avenue for diversifying international dialogue and solving problems that resist traditional diplomatic avenues. Scientists' supposed impartiality—due to their commitment to being objective and unbiased—open doors and unravel Gordian knots that diplomats' negotiating skills often cannot. Think of the nuclear deal with Iran where scientists got "the negotiations back to track," according to Richard Stone, the international editor for *Science Magazine* when politicians hit a dead end.[15] The epistemic premise—that science is international, transparent, and universal and thus scientists can achieve what diplomats might not—comes up often in the recent science diplomacy literature. In *New Frontiers in Science Diplomacy,* what has been perceived as the manifesto of the new era in science diplomacy, the assumption about the role of science in international affairs is obvious: "Science provides a non-ideological environment for the participation and free exchange of ideas between people, regardless of cultural, national or religious backgrounds."[16] History, however, has proved us wrong on several occasions.

Take the irony of the events that happened on 4th October 1957—a month before Eisenhower's and Khrushchev's speeches - as an example. On that evening, few American scientists gathered at the Soviet Union's Embassy in Washington, DC, for a rather informal party that marked the end of a week-long international scientific meeting of the Comité Speciale de l'Année Geophysique Internationale (CSAGI). A group of scientists from the U.S., the Soviet Union, and five other nations had been discussing their rocket and satellite research for over a week. Sergei M. Poloskov's talk on the Soviet satellite "Sputnik" and hints for an early launching, provoked wild speculation to the international audience.

Although American scientists were anticipating a Soviet move, the news that broke on the evening of 4th October caught them by surprise. "It's up," Walter Sullivan, the *New York Times* correspondent present to the event, whispered to the American delegates. Acting like a gentleman, the physicist Lloyd Berkner, official American delegate to CSAGI, congratulated his Soviet colleagues for the extraordinary achievement. A recently declassified CIA document affirms that a few minutes later the Americans left the reception and "reported back to a central point for the purpose of immediately going to work on their scientific computations."[17] The scientific value of internationalism ended at the embassy's front door.

Indeed, throughout the Cold War, scientific organisations functioned as important forums for discussion of nuclear issues between the United States and the Soviet Union. But these should not be considered as neutral intellectual spaces of scientific exchanges. Rather, international conferences were opportunities to gather national security intelligence and thus venues to enhance national security.[18]

Then came the IAEA

But October 4th was not yet over. Across the US, in the European continent, Sterling Cole, a Republican and member of the US House of Representatives, was taking his oath as Director-General of the International Atomic Energy Agency at Vienna's Konzerthaus. As he later recalled, "On October 4 I was elected unanimously by all of the country members. Also on October 4 was the announcement of the first successful Sputnik. I chided the Russians for deliberately using this date to demonstrate their terrific accomplishments in science technology, thereby putting news of my election as director-general on the back page.''[19]

The successful launch not only initiated fears that Americans dawdled in developing new technologies but also shadowed an international attempt to balance the East-West conflicts. The IAEA "could theoretically take on the entire world burden of developing the atom for

Figure 2. Sterling Cole, the First Director General of the IAEA, shown on the day of his inauguration, on 4 October 1957. (Courtesy of the IAEA archives, IAEA-ARC-AV-PH-01-01-C0184-005)

peace," Bernhard Bechhoefer explained.[20] Acting as the key adviser to the U.S. State Department and the Atomic Energy Commission throughout the negotiations of the Preparatory Commission for the establishment of the IAEA, Bechhoefer was among those who redefined security in the context of international cooperation and argued for the "lessening of East-West tensions." But as IAEA's later history proves, the tensions between East and West were rather intensified during the negotiations about the agency's safeguards system and the Nuclear Non-Proliferation Treaty (NPT).

Striving to become a centre of global authority in nuclear matters, the IAEA devised a comprehensive system to regulate nuclear threats and standardise technical processes, materials, and human actions on a global level. In his statement during the conference on IAEA's Statute, Lewis Straus, the chairman of the U.S. AEC, emphatically argued that "necessary safeguards to health and peace must accompany the development of the atom."[21] The IAEA clearly represented the shift from bilateral to multilateral nuclear diplomacy while nuclear security shifted from being the responsibility of individual states to becoming a key aspect of the agency's global regulatory role.

Numerous nations across the globe welcomed the establishment of the IAEA for diverse political reasons, but almost all shared the same expectation that went beyond the development of nuclear medicine or the training in nuclear science. The aim was to acquire nuclear energy to bolster industrial development. To several Member States development went hand in hand with the nuclear industry. To the IAEA however, the precondition for development was the application of a centralised safeguards system, which had two main objectives: a) to prevent the diversion of Agency assistance and fissile materials to military use; and b) to determine the standards of safe practice avoiding health and safety hazards.[22] Regardless of what collectively and diplomatically the Agency invoked, countries other than the P5 strongly criticised the perpetuation of safeguards. For example, the renowned Indian nuclear physicist Homi Bhabha argued, the agency's safeguards system was "always such as to widen the gap between the developed and underdeveloped countries... The most that can be said for the Agency's safeguards system is that it has a delaying effect on the spread of nuclear weapons."[23]

During the years following the

establishment of the IAEA, the safeguards system, which was gradually developed, encompassed both nuclear security and safety and brought a radical change in international affairs; multilateral and multinational diplomatic negotiations—necessarily administered by an international diplomatic organization—replaced the bilateral ones. The shift necessitated the mobilisation and interaction of multiple actors including diplomats, scientists and engineers, lawyers, third party liability experts, and economists to mention a few.[24] To create a niche within the United Nations family, the IAEA broadened the security agenda beyond the state and outside the military context to encompass the control of radioactive materials in the entire spectrum of nuclear activities worldwide. This move privileged the IAEA in forming a unique relationship with the United Nations sending its annual reports directly to the UN General Assembly, and whenever necessary, to the Security Council.

Nuclear security beyond the individual state

The IAEA is one of the most striking examples of an international diplomatic organisation making a significant difference in international affairs by embracing nuclear diplomacy beyond individual states and nations, despite its inability to directly enforce its recommendations. The early 1960s marked a unique period in nuclear history and diplomacy. It was the first time that an organisation could support - economically, politically, and organisationally - large-scale scientific projects, enlist international experts, have an in-house production process of the required equipment, ensure accessibility to many national research centres worldwide, and guard the implementation of multinational projects and their data from beginning to end. Thus, the approach that perceives nuclear science and technology as tools being used in bilateral agreements and controlled by big powers to discipline nations and retain the Cold War geopolitical order comes short. Rather, the shaping of nuclear science and the fashioning of certain technologies has been part of the kind of multinational, multilateral diplomatic negotiations that took place within the IAEA after the Second World War.

Among the most recent examples is the modernisation of the Safeguards Nuclear Material Laboratory - IAEA's laboratory used for the analysis of nuclear material samples from safeguards inspections. In 2012, the fifty-sixth regular session of the General Conference, the highest policy-making body of the IAEA, urged the Secretariat to develop a strategic overarching plan of action for basically modernising science behind safeguards. The modernisation plan was generously supported by individual member states and the European Union, which provides significant financial and technical support to the IAEA concerned especially about security.[25] Yet in addition to shaping nuclear science, IAEA's nuclear diplomacy advanced international law and devised legal instruments such as the Convention on Nuclear Safety (CNS), the Convention on Supplementary Compensation for Nuclear Damage (CSE), and the Convention on the Physical Protection of Nuclear Material (CPPNM), the only legally binding agreement for the protection of nuclear material, all key in sustaining the agency's nuclear regulatory role.

Historians and sociologists of science and technology have made significant contributions in analysing how science works and how is related to politics.[26] Yet, it is time to build bridges with other disciplines such as the history of diplomacy, legal history, science policy, and studies of international relations. Understanding current nuclear diplomacy demands profound transformations of our historiographies in many axes. Programmatically, the scope of what I call *Diplomatic Studies of Science* presupposes a perspective from the global south and a critical unpacking of IAEA's history and diplomacy away from the East-West understanding of global history. Historiography lacks a more systematic examination of the historical development of the UN system of international organisations and related agencies, of their impact on international affairs, and of the ways they have embraced science diplomacy throughout the second half of the 20th century. We, furthermore, lack a more critical reflection on the role scientists have played in international security. Historical analysis ought to bring front and centre the multi-stakeholders involved in defining international security. Those include diverse teams of diplomats, administrators, technical experts, scientists, insurers, and lawyers among others.[27] There is also a need to expand our geographical horizons. Moving outside of the headquarters of Ministries of Foreign Affairs and official diplomatic meetings, one should pay attention to several diverse sites including diplomatic receptions, international conferences, or exhibition halls where science diplomacy is taking place. Last, a comprehensive analysis of the ways science diplomacy could comprehensively demands a closer look at the materiality of diplomatic negotiations and gestures. Such an analysis will help to fully map the potentials of European science and technology in an increasingly demanding and rapidly changing international context.

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Endnotes

1. EEAS, 2017. EEAS is the European Union's diplomatic service. See also Cronberg, 2017.
2. Borger, Wintour, 2021.
3. InsSciDe was awarded in December 2017, receives funds from the EU under the Horizon 2020 scheme and involves a consortium of 15 partners. See http://www.insscide.eu/
4. For a detailed analysis of the use of history in international relations see Lawson, 2010.
5. Several science diplomacy studies have been recently published as a result of InsSciDE's initiatives. See https://www.insscide.eu/about/library/
6. Rentetzi and Ito, 2021.
7. Anonymous, 1957a, 359.
8. Rentetzi, 2019.
9. Krige and Barth, 2006.
10. Anonymous, 1957b, 360.
11. Rentetzi, 2021.
12. Progress Report, National Security Council, 21 December 1955, Disaster File Series, Box 5, NARA.
13. Anonymous, 1958.
14. On the establishment of the IAEA see Fischer 1997; Rentetzi, 2017; Roehrlich, 2016.

[15] Wolfe, 2015. See also Stone, 2015.

[16] The Royal Society. 2010.

[17] Announcement of Earth Satellite launching at Soviet Embassy Reception on 4 October 1957, Collection: Intelligence Warning of the 1957 Launch of Sputnik, CIA, no. 0000124275, NARA archives, https://www.cia.gov/library/readingroom/docs/DOC_0000124275.pdf

[18] Bulkeley, 2008.

[19] Interview with S. Cole conducted by C. Morrissey on August 24, 1978. W. Sterling Cole papers, col. No. 2081, Division of Rare and Manuscript Collections, Cornell University Library, page 11.

[20] Bechhoefer, 1958, 148.

[21] Conference on the Statute of the IAEA, United Nations Headquarters, 1956, Verbatim Record of the First Plenary Meeting, IAEA/CS/OR1, 20 September 1956, IAEA Archives.

[22] Anonymous, 1959.

[23] Mazari, 1979, 53.

[24] Kyrtsis, and Rentetzi, 2021.

[25] Rentetzi, 2017; Dixit, 2018.

[26] For example: John Krige. *American Hegemony and the Postwar Reconstruction of Science in Europe*. (Cambridge, Mass.: MIT Press, 2006).

[27] Kyrtsis and Rentetzi, 2021.

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ARTICLE

The Speedy Transmission of Corona Infections - Rebooting Science Diplomacy

Trithesh Nandan*

Trithesh Nandan

Introduction – 'Multiplicity of Infection' and Deficit in Diplomacy

Disease outbreaks on a pandemic scale are as ancient as humankind. Written history has several examples of past pandemics and the colossal scale of human suffering induced by them. In 2019, the Global Health Security (GHS) report, an index that maps health security and related capabilities, assigned low scores on globally catastrophic biological risks (GCBRs) to 75 per cent of the 195 countries that it ranked.[1] The report mentioned, "If left unchecked, high-consequence biological events can become GCBRs, leading to enormous suffering; loss of life; and sustained damage to national governments, international relationships, economies, societal stability, and global security."[2] A year later, in 2020, more than 90 million people were infected with symptoms of the coronavirus in 219 countries and lost more than two million lives.

True to the GHS prophecy, most countries were ill-equipped to handle a crisis like this and the scale of corona infections has ravaged the world; the economy plummeted beyond imagination, unemployment created shock waves and the confinement during the lockdown led to mental trauma – all in a single year. The 'global lockdown', a countermeasure to contain the virus disrupted diplomatic activities, limited human contact,

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and reduced multilateral and bilateral visits by the country's leaders, ministers, and bureaucrats. The beginning of 2021 has not put a brake on the rising infections and governments across the world still face challenges of a mutated version of the virus that brought the world to a standstill. New waves are being reported from different parts of the world and the 'new normal' is still elusive. Worldwide infections have reached more than 120 million by March 2021.

The Coronavirus pandemic has put several question-marks on international relations, diplomacy and the functioning of multilateral institutions across the world. In a globalised and better-connected world of the 21st century that appears far more prepared to handle a pandemic as compared to the past, the unchecked and ever magnifying rise of Covid-19 points to the lapses in global healthcare governance. On a broad basis, there can be three major aspects where the world failed in handling this crisis.

Firstly, the lack of concerted initial response at a global scale which could have curbed the outbreak in the early phase. There are more than seven thousand diplomatic posts in the world with a total of 4,849 embassies/high commissions, 1,887 consulates and 373 permanent missions and 211 other diplomatic posts.[3] Despite the presence of such a huge diplomatic network among countries which unlike the last pandemic is powered by modern technology and fast communication, there was a lacklustre global response in the early phase of the outbreak. Most countries initially responded individually to 'invisible threats' and remained in national silos, except for some countries, eroding the effectiveness of international diplomacy. This raises the question: why countries around the world can converge on military threats or other crises but there is no country-to-country link to address the pandemic? The failure of international coordination and inventory management of life-saving equipment, laboratory testing kits, ventilators, personal protective equipment (PPE), surgical masks, N-95 masks, respirators, hand sanitisers, gloves, face shields, disposable gowns and so on in the early phase of the pandemic despite having modern diplomatic networks remains perplexing.

Secondly, the failure of the international organisations to anticipate the crisis and share real-time threat information as a part of collective defence against the outbreak is also astonishing because we are living in the information age. According to the Yearbook of International Organisations, there are around 73,000 international organisations throughout the world, out of which 41,000 are active.[4] Nevertheless, it failed to control the spread of the virus, the rise in deaths and disrupted the applecart of the world order. The United Nations and its subsidiaries including the Geneva-based World Health Organisation (WHO) are part of more than forty thousand international active international organisations. The capacity of the United Nations system to respond to pandemics has been questioned. The WHO has been under scrutiny due to the alleged mismanagement of coronavirus infections and delayed response to Covid-19. As the pandemic enters the second year and into a significant phase of vaccine deployment, there is still a lack of consensus at the World Trade Organisation on the waiver of intellectual property (IP) for Covid-19 drugs and vaccines which has divided rich and poor countries. The coronavirus pandemic brought to light the weakness of the international system and raised a question mark about the role global institutions play in the resolution of the health crisis. Yet the very scale and expense of the tasks faced, the continuing suspicion among states and the tendency of great-power disagreements to be dragged into such organisations make them unable to assume overall responsibility for managing pandemics.[5] Even the G20 and international organisations have not been able to establish a united global front against the pandemic.

Thirdly, the absence of global solidarity and a guiding force that many countries might have abided with is also startling. The UN Secretary-General Antonio Guterres said in October 2020 a divided world has failed the Covid-19 test. "The Covid-19 pandemic is a major global challenge for the entire international community… Unfortunately, it is a test that, so far, the international community is failing," Guterres expressed concern at the lack of coordinated efforts, even after ten-month of the crisis.[6] Before Guterres, announcing an independent evaluation of the global Covid-19 response on 9th July, the WHO Director-General Ghebreyesus warned, "The greatest threat we face now is not the virus itself. Rather, it is the lack of leadership and solidarity at the global and national levels."[7]

Since the end of the Second World War, there has been no crisis until the covid-19 outbreak that had inflicted such hardship on individuals, nations, and international systems - all at one go and that too at this scale. The pandemic also exposed the lack of healthcare resources across countries- be it advanced, developing, or underdeveloped countries. It also highlighted the lack of preparedness in both rich and poor countries. Even the world's largest economy and biggest military powers were subdued by the virus as the world watched how over a hundred thousand infections and thousands of deaths were being reported from the United States daily. The fault lines exposed by the virus certainly necessitate the need to focus on healthcare and scientific partnerships instead of securing military cooperation during bilateral and multilateral visits of country heads.

Science the solution – 'Science Diplomacy' in times of COVID-19

Science has provided society with long-standing cures from time immemorial. Scientific findings have emancipated human lives from the dark ages into the modern world - theory of gravity, the concept of evolution, the discovery of penicillin, electric current, airplanes, computers, mobile phones, and vaccines – are a few of the many inventions that have not only eased our lives but have also made the world healthier, prosperous, and better connected than it was ever before. For the sustained development of an individual country as well as the world, scientific research and innovations form an important thread. Science diplomacy, through sharing of knowledge and technology, gives a healing touch in hard times like this. The need to link science and diplomacy seems to be the need of the hour in these taxing times.

The International Health Regulations (IHRs) were adopted by the United Nations more than a decade ago, immediately after the outbreak of severe acute respiratory syndrome (SARS), to expedite the international coordination during public health emergencies.[8] However, coronavirus pandemic has exposed diplomatic networks and cooperation among countries especially in the community-centred care policy during the pandemic in the initial months of corona infections, as the frontline healthcare workers lacked pandemic preparedness including shortage of equipment, as well as the limited ability for virus testing and monitoring. The approach of traditional healthcare systems to disaster preparedness and prevention has demonstrated intrinsic problems, such as failure to detect early the spread of the virus, public hospitals being overwhelmed, a dire shortage of personal protective equipment, and exhaustion of healthcare workers.[9]

By April 2020, when the world needed a steady supply of medicines, medical supplies and personal protection equipment with rising corona infection cases, many countries resorted to hoarding of such products to meet the critical demand. According to the World Trade Organizations' export prohibitions and restrictions note on 23 April 2020, "Eighty countries and separate customs territories introduced export prohibitions or restrictions as a result of the COVID-19 pandemic."[10] When healthcare workers rely on personal protective equipment to protect themselves and their patients from being infected and infecting others, these items like facemasks, shields and ventilators came under export prohibitions and restrictions category list of countries. Face and eye protection, protective garments and gloves were the three of the most restricted items by countries in the world (Table 1). In addition, when there was a genuine demand for these items from the most infected countries, stocks frequently sold to the highest bidder.

As the import-reliant countries desperately needed medical products for their citizens, the lack of global

Table 1 - Export prohibitions and restrictions by categories of products because of COVID-19

Categories of products	No. of countries introduced export restrictions
Face and eye protection	73 countries
Protective garments	50 countries
Gloves	47 countries
Sanitisers & Disinfectants	28 countries
Pharmaceuticals	20 countries
Foodstuffs	17 countries
Medical devices including ventilators	10 countries
Other medical supplies	10 countries
Covid-19 test kits	6 countries
Soap	3 countries
Toilet paper	2 countries

Source: WTO data published on April 23, 2020 cooperation became more apparent. It's no exaggeration to say that illness does not see race, religion, and material possession and a virus-like this doesn't consider historical, cultural, and economic differences among countries before transcending international boundaries. Scientific innovations in health and swift international coordination through diplomatic channels are capable of dramatically reducing the risks for human life and might have given hope to millions of people during these dark times. Scientists follow the path of invention and discovery to eradicate disease, but its fruits can be made available for a larger audience through international coordination enabled by diplomatic negotiations. This is only possible if the scientific community, universities, researchers, pharmaceutical companies, and diplomats come together to eradicate/ control diseases like COVID-19, as well as make internationally accepted plans to handle similar situations in the future. Beyond increasing the supply for their domestic needs, a crucial role for countries during the pandemic is also to coordinate international efforts to prioritise supplies for the regions that are the worst hit.

The focal points of typical bilateral as well as multilateral diplomatic negotiations largely revolved around pressing issues such as climate change, arms control, humanitarian aid, etc., while the scientific exchange in the field of health through diplomatic negotiations has remained mostly at the bottom of the agenda. Despite being at loggerheads during the Cold War, the United States, and the former Soviet Union (now Russia) agreed on series of arms control agreements. The international community negotiated key conventions on chemical and biological weapons, climate change agreement, etc. Similarly, in 1996, the Comprehensive Test-Ban Treaty (CTBT), advocating a global ban on nuclear testing for military purpose was well received by most of the countries. In recent years, among the major initiatives taken by Group of Twenty (G20) - the largest forum for international cooperation in terms of combined GDP and population, was to develop a coordinated response to handle the 2008 global financial crisis. There have been various degrees of consensus among 195 signatories of the 2015 Paris Agreement on measures to combat global warming as well as climate change.

However, similar commitments at the global level are missing when it comes to public health issues like disease control and providing access to basic healthcare for most of the global population. Historically, the world has only engaged in science diplomacy in times of need. In today's foreign policy doctrines, a country's interest is mainly safeguarded in foreign lands by emphasising defence, economic, and cultural exchanges and hence attaché/ counsellors in foreign missions – embassies and high commissions largely promote these aspects of a country's national interest. Expect few advanced countries, the diplomatic positions of most countries have no space for scientific wings/science attaché and counsellors. The presence of a science attaché might have served as a valuable conduit to an embassy's urgent need for medical equipment during the initial months of the covid-19 pandemic. It's important to mention that despite the ongoing pandemic, there are no talks about a global treaty to control health outbreaks of this scale. In February 2021, the European Council on COVID-19 and health demanded an action towards an international treaty on pandemics within its framework.[11] A pandemic treaty under the joint auspices of WHO and the UN seems the most viable way forward given the urgency and the implications of the current pandemic beyond health to livelihoods, economies, security, solidarity, and human rights.[12]

It's now obvious that there is a significant economic benefit for countries to invest in public health and eradication of diseases. According to the study done by the magazine *Vaccine*, the global polio eradication initiative (GPEI) by 2035 is approximately $50 billion.[13] Unilateralism does not work in health care, nor does it work in government health policymaking. Governments cannot tackle most challenges of global health working entirely on their own. It took a series of global meetings and resolutions to put an end to diseases such as chickenpox, plague, cholera, and highly contagious polio.

Curing the pandemic – 'Vaccine Multilateralism' and 'Open Science'

Vaccines are an effective means of preventing disease. If vaccinated, the body trains the immune system for antibody formation, when exposed to a disease. Immunisation not only protects lives but also protects the economy. The vaccines are important because modern vaccines have saved more lives than those that were lost in the World Wars during the 20th century.[14] To cure the corona pandemic, scientists around the world took a speedy effort to launch a vaccine within a year of the pandemic. The fastest any vaccine had previously been developed, from viral sampling to approval, was four years, for mumps in the 1960s.[15]

But during corona outbreak, and now during the vaccination phase, experts have pointed to vaccine nationalism. Vaccine nationalism denotes how a country ensures maximum supply of vaccines to its citizens, thereby depriving citizens of other countries of the right to the vaccine. Who benefits from such vaccine nationalism? It is the wealthy countries that usually obtain the right to be vaccinated by hoarding the coronavirus vaccine. Who is suffering from colonisation of the vaccine? Poor countries will have to wait until high-income and middle-income countries vaccinate all their people, which will have grave consequences for their citizens. In its study, the International Chamber of Commerce (ICC) Research found that the world is at risk of losing trillions of dollars if the vaccine is not supplied. It found that the global economy will lose as much as $9.2 trillion if governments fail to ensure developing economy access to COVID-19 vaccines, while the rich countries stand to lose $4.5 trillion.[16]

Vaccine nationalism comes with a cost for the rich nations, as the ICC report mentions, "The economic costs borne by wealthy countries in the absence of multilateral coordination guaranteeing vaccine access and distribution range between $203 billion and $5 trillion, depending on the strength of trade and international production network relations.[17] So, equitable distribution is not only the need of the hour, but collaboration to ensure a smooth supply for all countries of the world needs a strong diplomatic effort. However, the Global Vaccine Alliance – Gavi has risen to assist in vaccinating poor countries. The vaccine nationalism can be stopped through multilateralism where global institutions like the UN and WHO can play a key role by bringing nations on a common platform to tackle vaccine nationalism. These institutions must create a financing mechanism, so the poor nations don't turn down the vaccine for their citizens.

Another concern during the pandemic is the fragmented scientific and policy environment in different countries posing a challenge for 'open science'. Any strategy to fight the pandemic should also be based on 'open science' when there is a greater openness to science and data sharing. In October 2020, the heads of three UN agencies - Audrey Azoulay, the Director-General of the UNESCO, Tedros Adhanom Ghebreyesus, Director-General of the WHO and Michelle Bachelet, UN human rights chief (OHCHR) appealed for a global push towards "open science" to save humanity from the current pandemic.[18] Until COVID-19, only 25 per cent of scientific publications were openly accessible and a minority of peers used to use the resources. Science Diplomacy is needed to build the necessary bridges between states, science, and the industrial sector, so that urgently needed knowledge and robust, high-quality data can be generated and sustainably exchanged.[19]

During the pandemic period, open resources are likely to bring out more information and provide early analysis to fight the disease. There has been a concerning adoption of "Open Access" – some publishers gave free access to COVID-19 research but neglected to give access to older articles in virology, serology or vaccination, for instance, which would have made knowledge more accessible and resulted in a more holistic research approach.[20] There are more ways the world can work together - open science practices, open access, open-source, open data and open peer-review. UNESCO has described Open Science as a "true game-changer": by making information widely available, more people can benefit from scientific and technological innovation.[21]

Filling the leadership void – India and science diplomacy

As few rich countries around the world promote the agenda of vaccine nationalism, India has taken the lead in 'vaccine maitri' to counter vaccine nationalism, as a key diplomatic initiative. By mid-March 2021, India has supplied 58 million vaccines to 71 countries, according to a statement by the Ministry of Health and Family Welfare in a written reply to the Rajya Sabha.[22] Of the 71 countries, at least 37 have got the vaccines free, considered by many as a healing touch at the time of the pandemic. As India is the largest vaccine producer in the world, this is a natural extension of the country's pivotal role in the global pharmaceutical industry. India has the third-highest number of corona cases in the world till mid-March 2021, after the United States and Brazil. Despite this, the country has never been hesitant to take global leadership during the pandemic. India has supplied vaccines to at least 50 per cent of the Least Developed Countries (LDC) and one-third of the Small Island Developing (SID) countries.

Today, India is considered as the centre of the vaccine revolution, just like it led the software revolution in the 1990s and 2000s. As with the software revolution, India's information technologists (IT) ruled the world, the country's corona vaccine initiative will heal humankind. The software industry in India has not only provided cost-effective administrative support but also advanced the digital transformation agenda in global business. The global software revolution brought India to the map of the world and its pursuit of vaccine diplomacy is likely to bring the country on the health map.

As India produces a broad range of vaccines, an increased number of satellite launches, more scientific papers published and breakthrough in scientific innovations at low cost, the world is turning to the country for a solution at this crucial time. India's vaccine initiative has got a boost from four Quad countries — the United States, India, Japan, and Australia. "With Indian manufacturing, U.S. technology, Japanese and American financing, and Australian logistics capability, the Quad committed to delivering up to 1 billion doses to ASEAN, the Indo-Pacific, and beyond by the end of 2022," according to the press briefing by the White House after the Quad meet.[23]

Prime Minister Narendra Modi discussed making medicines accessible to the whole of humanity. During the initial month of corona infections, India even carried out medical diplomacy. India engaged with the world by sending life-saving drugs and medicines far and wide. First, India commercially supplied 560 million tablets of Hydroxychloroquine (HCQ) and 53.13 metric tonnes of the active pharmaceutical ingredient (API) of HCQ to 82 countries and it also commercially supplied 154 million units of paracetamol and 1605 metric tonnes of API to 96 countries to counter the coronavirus.[24] Second, despite the burden of COVID-19 cases at home, India managed to send medical teams to the Maldives, Mauritius, Madagascar, Comoros and Seychelles.

Not only, India has been championing vaccine multilateralism, it is also advocating for cheap pharmaceutical products. In October 2020, India and South Africa led 40-countries that expressed concern at the World Trade Organization (WTO) on intellectual property (IP) rights related to COVID-19. New Delhi argued that Intellectual property could be a barrier to access to the corona vaccine by many poor countries as they cannot get the vaccine because of the high cost. Although IP drives innovation, pharmaceutical firms tend to increase costs by introducing new products. India fears that when the world has been facing a pandemic, major pharmaceutical companies and rich countries may benefit from innovations to combat the coronavirus pandemic.

At the WTO Council meeting on Trade-Related Aspects of Intellectual Property (TRIPS), the proposal for waiver of the patent was submitted. India argued for avoiding barriers to the timely access to affordable medical products including vaccines and medicines or scaling-up of research, development, manufacturing, and supply of essential medical products.[25] Since independence, India has consistently raised the concerns of poor nations in the multilateral forum. In the WTO meeting on TRIPS that followed in October 2020, New Delhi continued to raise the issue. Its statement said, "On one hand, these countries are buying up as much of the limited supply as they can, leaving no vaccines in the pie for developing and least-developed countries. On the other hand, and very strangely, these are the same countries who are arguing against the need for the waiver that can help increase the global manufacturing and supply to achieve not just equitable, but also timely and affordable access to such vaccines for all countries."[26] The WTO meeting attended by 164 members in January 2021 failed to achieve consensus, opposed principally by the European Union, the United States, Switzerland, the United Kingdom and Japan.

Conclusion – The 'ten commandments' for a better world

The obstacle to safe and effective vaccines at affordable prices because of the Intellectual Property Rights keep vaccines out of reach for most low-and middle-income countries. The fairness of the distribution of the vaccines has been questioned while the world is not in normal times. How should the supply of corona vaccine be allocated geographically throughout the world? WHO Director-General Ghebreyesus termed that the world is on the "brink of a catastrophic moral failure" due to inequitable vaccination programme. In the Biblical text, the 'Ten Commandments'were intended to provide protection, guidance and wisdom. Ordinary people suffered immeasurably in the aftermath of the COVID-19 crisis and the post-COVID world needs 'Scientific Commandments' to resurrect.

First **-** An affordable vaccine is urgently required, especially in low-income countries. There is no way to maintain good health without access to affordable pharmaceutical products. The world needs an international agreement on a vaccine for fair distribution in all countries to combat the coronavirus pandemic.

Second - There is considerable logistics involved in deploying the vaccine. For instance, corona vaccines from Moderna and Pfizer can only be stored at minus 70-degree Celsius. It is an enormous cost to any country, for example, India does not have that kind of infrastructure. A complete redesign of the system costs a great deal of money. The conclusion of an international agreement on vaccination logistics will assist poor and low-income countries.

Third - In 2015, the world signed the Paris Agreement, a globally binding treaty on climate change. It was an agreement to address the rapidly escalating climate and reduce global warming. Since the end of the Second World War, there have been other international agreements aimed at securing humanity. The 2019 Global Risks Report cautions that infectious diseases have been identified as one of the top ten risks in terms of impact for the next 10 years. To be prepared for such a health hazard situation, the world needs a 'global pandemic treaty' to deal with future outbreaks.

Fourth - Many countries have set up an Early Warning System (EWS) to deal with potential disasters (floods, drought, fire and tsunamis) that threaten peoples' lives. The Public Health Emergency of International Concern (PHEIC) under the International Health Regulations was established in 2005. A PHEIC is meant to mobilize an international response to an outbreak. The WHO fell under criticism over the delay in announcing a PHEIC after the cases of corona infections came into the picture. A new warning system exclusively for the disease outbreak is the need for the time that can be used to carry out surveillance and predict it.

Fifth - During World War II, there was a great demand for a strong international organisation to create a more stable and peaceful world. In 1942, US President Franklin D. Roosevelt coined the term 'United Nations' and it came into existence three years later in 1945. Seventy-five years later, as the pandemic devastates the world, a global science monitored institution on the model of the UN is the need of the day. The new institution should be tasked with responding to future pandemics and epidemics, as many experts believe that the WHO has exceeded its usefulness.

Sixth - According to Oxfam report, the Covid-19 has caused an additional $11.7 trillion costs to the world economy. It is a tremendous loss that has largely destroyed the economic conditions of the poor and low-income countries. A dedicated global fund to address such a global pandemic is one way to treat future disease outbreaks. There should be a requirement that countries contribute to the budget.

Seventh - Another point is to ensure the international fund for scientific innovation that has the potential to improve the lives of the world's poorest people. All countries should part of the innovation fund, which can play an active role in the response to post-pandemics and other such issues.

Eighth - In a post-COVID world, foreign policy should prioritise the need for healthcare and hospitals agreements and greater pharmaceutical collaborations.

Ninth - In the 1960s, the Green Revolution tackled food challenges in developing countries. Therefore, many developing countries, like India, have enough food to feed their population. The overall burden of illness, too, has tremendous economic costs. On the lines of 'Green Revolution' a 'Health Revolution' should be initiated to meet the health standards across the globe.

Tenth - A crucial task for the world in the post-COVID world is to enhance the interaction between science and foreign policymakers. Another key issue is to develop the 'open science' policy as an important element in bilateral and multilateral discussions. To do so, science diplomacy needs a helping hand that can be accomplished by appointing science diplomats to foreign missions. The world needs to embrace science and its benefits through diplomacy sooner and an inter-disciplinary approach to global health to prevent, detect, and respond to a high-impact biological threat.

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ARTICLE

A New Generation of Trainings on Science Diplomacy for Global Challenges: Insights from two European Projects

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Introduction

The connection between global health and science diplomacy (SD) is anything but new. The intensification of world trade from the mid-19th century may have increased the international risk of epidemics, but it also fostered a greater exchange of scientific information. Efforts to collect, mutualize and standardize epidemiological information across states, especially between diplomatic and health administrations, proved that science diplomacy could de facto fight global crises (Paillette, 2012).

Lo Tempio et al (2020) have shown that the COVID-19 pandemic emphasized the need for better scientific data collection and dissemination for policymakers. We argue that the same holds for diplomats. The pandemic made obvious as well how valuable scientific and diplomatic relations are when they are built on trust and that merit must be attributed to trust in science-based knowledge networks, too (GualSoler and Oni, 2020; Melchor et al, 2020; Allegra and Calkins, 2020; Aukes, 2020). While Science Diplomacy (SD) confirmed its importance for transnational coordination and action, the crisis has nonetheless exposed a lack of interactive spaces for exchange among stakeholders from policy, diplomacy, society, and science (Young, 2020) - in this paper, the notion of 'science' is used in its broadest sense, including natural, social, and human sciences. Specifically, the crisis has revealed weaknesses in the interface between scientific research and international relations (Colglazier, 2020). Thus, it has shed a clear light on the need for the development of specific training activities that are meant to improve this interface.

Two European research and training projects were dedicated to this development, funded by the European Commission (EC), namely *Using Science for/in Diplomacy for Addressing Global Challenges* (*cf.* S4D4C, 2020a) and *Inventing a Shared Science Diplomacy for Europe* (*cf.* InsSciDE, 2020a). They were established based on the understanding that SD is a major tool to deploy in national, regional, or transnational actions addressing global challenges, and that additional research was required to grasp its limits and opportunities. In this paper, we share the experiences we made in these two projects in designing and executing SD training, most recently in completely virtual formats. In Table 1, we highlight stakeholder needs, outline the forms and targets of our recent training actions, and discuss insights to be applied in future iterations of training programs that may reinforce SD capacity and quality.

Needs related to SD trainings

Currently, SD trainings are multiplying, and hundreds of requests are typically received for only a few dozen seats. A vast number of SD trainings are developed by science-related organisations, such as the Center for Science Diplomacy of the American Association for the Advancement of Science (AAAS) and The World Academy of Sciences (TWAS) (Mauduit and GualSoler, 2020). As most trainings are organised by the U.S. and European institutions, a somewhat circumscribed SD approach might result despite their ambitions of global reach. However, the emerging of new players in this field of action, which are rapidly growing in strength and becoming increasingly important actors, gradually changes the picture. As an example, we can point to the São Paulo School of Advanced Science on Science Diplomacy and Innovation Diplomacy (*cf.* InnSciD SP, 2020) and to the initiative of the Indian Research and Information System for Developing Countries (RIS) which together with the National Institute of Advanced Studies (NIAS) launched a project for SD in 2018, funded by the Indian Department of Science and Technology with a dedicated capacity-building focus, the Forum for Indian Science Diplomacy (*cf.* FISD, 2020). These initiatives purposefully and fruitfully broaden the scope of the global SD discourse by engaging in the development of training design and by involving additional trainers and experts from their national contexts and from all over the world.

A needs assessment survey from 2019 (*cf.* Degelsegger-Márquez et al., 2019) documented strong individual demand for training from the side of SD actors, including a desire for better awareness of the SD stakeholder landscape, of formal Science, Technology, and Innovation (STI) agreements, and local STI activities. Proficiency in negotiation, science communication and networking is in considerable demand as well. Respondents are interested in improving their knowledge of both the concept of SD itself and of how international relations and science are linked. Are those needs currently met by the trainings on the market?

The EU science diplomacy trainings

The trainings offered by S4D4C and InsSciDE are described in Table 1. They are based on the socio-scientific and historical research activities of the projects,

Table 1: Overview of S4D4C and InsSciDE Science Diplomacy (SD) Trainings

Training	Objectives	Training format	Target group and participants	Teaching format and design	Content
S4D4C Open Doors Programme (December 2018-April 2019)	Raise awareness of SD in the scientific community. Enhance networking with SD stakeholders and policymakers.	Series of consecutive meetings in different settings (Madrid, Brussels, London, Bonn, Berlin).	Early-career researchers from Europe interested in SD and related policymaking. Applications: 126 (plus 62 not eligible due to not targeted countries). Participants: 5	Networking events. Field trips to embassies and other SD bodies (research ministry, research funding agencies, European Space Agency). Workshops. Participation in SD events (as speakers).	SD concepts. Career Development. Skills. Exchange on the mode of operation in SD with diplomats.
S4D4C workshops in Trieste (August 2019) and Vienna (November 2019)	Understand the state-of-the-art of SD in Europe. Convey SD skills to work in the field.	3-day in-person trainings.	An adequate mix of early-, mid-, and senior-career scientists and diplomats from EU and Neighbourhood countries Applications: 400 (Trieste, 300 were not eligible due to not targeted countries) and 200 (Vienna, 110 were not eligible due to not targeted countries) Participants: 25 (for each training)	Theoretical and case study related input. Simulation exercises. Group work. Networking. Visit an international research facility. Social activities.	Science Communication. International science system. Negotiation skills. Case Studies: Water Diplomacy, Open Science and Global Health. Career Development.

Table 1 continued...

Table 1 continued...

S4D4C European Science Diplomacy Online Course (starting June 2020)	Meet the growing demand. Raise awareness and improve understanding of SD. Share results of case study research and conceptual work.	15-hour online training as a Massive Open Online Course (MOOC). Free of charge. Registered users manage their own time. Completion of the course is rewarded by an S4D4C official certificate.	Professionals with an interest in SD and a diplomatic or scientific background: career diplomats, embassy staff, counsellors/attachés, career scientists, policymakers, graduate and undergraduate students. Participants: Some 5000 (registered users from all over the world)	Readings. Recorded video interviews of experts. Self-assessment and quizzes.	SD conceptual frameworks. SD stakeholders and networks. European Union approach to SD. National, regional, and thematic SD approaches. Required skills to operate in SD. Overview of some S4D4C and InsSciDE empirical case studies.
S4D4C interactive online-seminar series (October – December 2020)	Foster interaction and networking. Provide opportunities for engagement as a spin-off to the online course. Discuss questions about online modules.	Series of six interactive 2-hour online seminars.	Registered users having completedS4D4C European SD Online Course and prospective users. Applications: 650 (1st seminar) Participants: 160 from all over the world	Panel discussion. Interactive chat. Break-out sessions. Different interactive exercises (role-plays, elevator pitches, etc.) Instant surveys.	Same as in the online course above.
InsSciDE Warsaw Science Diplomacy School (June 2020)	Acquire general knowledge, deepen conceptual and historical understanding of SD. Grasp the 'extensive paradigm that is science'. Network across disciplines. Observe transnational practices, considering a European perspective.	A virtual 5-day course in real-time (preceded by S4D4C MOOC). >30 hours (lessons, team exercises) hosted on Zoom. Rigorous application process (essays, motivation letter, nominations, etc.). Free of charge. Completion rewarded by InsSciDE certificate.	Professionals or advanced students of all disciplinary backgrounds and geographic origins interested in SD and about networking and contributing to the field. Applications: 84 (complete) Participants: 28 from 27 countries	Panels and lectures. Intensive small-group exercises and discussions led by InsSciDE experts. 3 collaborative mock deliverables. Out-of-class online interactions encouraged (e.g. yoga). Post-course one-on-one guidance from matched science diplomat.	Historical case studies on pandemic diplomacy; biodiversity protection; scientists' role in colonial expansion; the co-construction of the UN Law of the Sea. Critical questions on risk, safety and security in the practice of SD. Power and strategy: concepts and simulations. Panels of experienced science diplomats.

Source: Own compilation.

the already mentioned needs assessment survey and vary across objectives and format. Due to the pandemic, InsSciDE's intended face-to-face summer school was rapidly transferred online. S4D4C had already planned a massive open online course but was surprised by the huge enrolment which was, in part, certainly fostered by the pandemic. The table displays the target audience, the profile of actual participants, teaching approaches and content, thus, a small number of criteria allow us to differentiate the trainings in terms of basic characteristics.

The criteria that were chosen for this systematics form a very simple typology. It is more than obvious that a more complex systemisation or, taxonomy or the intent to even conceptualise the trainings against the background of a theoretical pedagogical framework do lead to additional needs and challenges. Here, we can only concentrate on some empirical observations and evidence.

Insights from the trainings and their evaluation

What are the learnings from these trainings? Which insights may be valuable for future training concepts and designs? Formal and informal feedback from participants and instructors of the SD trainings in the two projects were collected. In this chapter, we concentrate on the most successful dimensions of the trainings that could be identified. The results can be bundled by formulating three conclusions:

Health diplomacy provides cases and content for SD teaching

The central question of training content naturally depends on the trainers' reach and resources. In general, content such as skills (e.g., negotiation), science communication, information on the international science landscape and the conceptualisation of SD is highly valuable. Case studies were welcomed by participants and observed to be highly effective in illustrating the possibilities and complexities of the SD interface (Šlosarčík et al, 2020).

Health diplomacy (HD) cases are easier to use and seem to better accomplish the needs of trainings than SD in general. These cases can thus be used as an example in SD teaching (Told, 2019a and 2019b), as the practices of HD and SD are closely interrelated. HD has already been declared an area in which national interests, which are still prevalent in some arenas of discussion (e.g., health security), might be overcome (Kickbusch et al, 2007). This is crucial for the development of an internationally consolidated narrative and agenda to tackle a pandemic crisis (Valenza, 2020). Still, a holistic vision of influences on the pandemic situation would usefully integrate cases in related sectors such as biodiversity conservation, water diplomacy and open science.

Diverse cohorts: the magic happens when different SD backgrounds come together

About teaching format and participants' groups, we found that the recent EU SD trainings overall attracted more scientists than diplomats or other stakeholders involved in international affairs. The reasons for this might be diverse: is it due to training content, to marketing and outreach, to career or intellectual incentives, or perhaps even to the actual distribution of different professions? This is an area where further research is needed.

Our evaluations have shown us that trainees perceive the experience to be particularly enriching if there is a diverse group of participants. Our trainings welcomed participants from a wide spectrum of backgrounds, disciplines, roles and cultures, and supported their learning to deal with ambiguity - a useful skill to address the diversity of contexts and approaches in SD. *Transdisciplinary SD training* that takes such differences into account, e.g. by setting specific and learner-oriented goals, can build the ability to communicate clearly and effectively and increase mutual understanding on the interface between science and foreign relations. "When you put all these people together with very specialized knowledge and a common interest, that's when the magic happens" (Hardy et al, 2020:20). We saw that a co-constructive learning process supported successful knowledge transfer. We also learned that SD is a truly global topic of interest. While we anticipated enrolment by European stakeholders or those from the European neighbourhood, a vaster set of candidates ranging across most continents applied to attend our trainings. A transnational approach appears thus to be key when focusing on SD for addressing global challenges.

Pedagogy: experiences beyond the classroom heighten SD learning

While lectures and readings were valuable for conveying general SD knowledge and concepts, opportunities for sharing of practitioners' personal field experience and/or expertise, such as panels, recorded videos or direct (if virtual) meetings, were integral to achieving the learning objectives. Moreover, the active engagement of participants through debate and discussion applied exercises, role-plays and simulations were identified as fundamental to the success of both live and virtual trainings. The knowledge and skills gained through interactive and experiential formats provide a strong basis for the individuals' sense-making process and learning to penetrate complexity.

It is furthermore helpful for learners that they are allowed to *network and socialize outside the classroom.* "Soft" components, such as joint dinners, excursions or connecting online contribute to the learning success. In the virtual InsSciDE Warsaw Science Diplomacy School (WSDS) this entailed frequent engagement in small teams beginning before the course itself, as well as the availability of several online resources for students, who actively seized opportunities to engage (for instance, ad hoc teams drafted articles reporting and assessing the school that were subsequently published online). Students gave top ratings to "fun" elements of WSDS such as online yoga and dance tutorials. They also expressed great satisfaction with being matched with an SD expert for a personal guidance session following the completion of the course. Similar feedback was received in the first S4D4C interactive online seminar, where the chat function was used for parallel "out of the box" discussions with SD researchers.

These observations, as said, are the first collections of signs of empirical evidence of significant control variables in the planning and implementation of trainings in the action field of SD and in particular the interconnection between science and diplomacy. They do not yet satisfy analytical verification or conceptual model building and need to be specified. Further aspects may be crucial for future SD trainings in the global context. Current limitations of SD trainings include a geographical choice of training content and trainers, cultural differences in learning styles, variety of thematic content and case studies, transversal characteristics and systemic settings of SD and numbers of SD actors involved. Also, about training content, a critical reflection of the SD discourse and practices could enrich the learning experience (Rungius and Flink, 2020; Flink, 2020; Ruffini, 2020). Possible ways to address these variables would be to build transnational partnerships between organisations and actors involved in SD practices and teaching to include different perspectives and outreach. These partnerships would not necessarily need to be limited to selective occasions but would ideally be sustainable, thus facilitating an open exchange of experiences and objectives for SD trainings. In addition, the quite recent scientific and policy-oriented publications on SD that address topics such as science diplomacy matters, needs for systemic change and case studies on SD for global challenges would enrich training content (*cf.* S4D4C, 2020b; InsSciDE, 2020b; Young et al, 2020). Furthermore, material that deals with SD training design, like evaluations and training materials, e.g., curricula recommendations and toolkits for trainers, are also helpful resources, especially for new players (S4D4C, 2020c and 2020d; Told, 2019b). We would therefore encourage SD actors to act in the spirit of open access and to make their concepts and outputs available.

Conclusion

Scientific research, policy-making and diplomatic action often share the common goal of addressing global challenges, but current trainings do not sufficiently take the global perspective into account yet. This could be addressed by ensuring networking and partnering of SD organising institutions with different geographical background, a holistic thematic approach, and the use of available material on SD practices and trainings. Stakeholders are motivated by different systems of incentives that can hamper fruitful interactions (Gore et al, 2020), and they may lack relevant skills in their toolbox (Melchor, 2020). Fostering insight and capacity building at the personal and institutional level, as well as directly contributing to network building in the training setting, can bridge these gaps to integrate science and diplomacy. We assess the MOOC to be a promising and sustainable means of scaling efforts in building and increasing capacity in SD in times of COVID-19 while requiring complementary interactive online seminars or sessions to draw the full benefits. Our trainings presented above, virtual or in-person, have learning and networking elements that may help prepare the next generation of scientists, diplomats, and boundary-spanning professionals in SD to anticipate and face global crises.

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PERSPECTIVE

Circulation of Science Diplomacy: Exploring the Motion of Ideas

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Introduction

Borrowing a phrase associated with the evolution of European studies,[1] science diplomacy is experiencing the transformation "from boutique to boom field" (Keeler, 2005). Looking from Europe and beyond three EU supported projects,[2] science diplomacy is characterised by the denationalisation of diplomacy and the internationalisation of science (Arnaldi and Tessarolo, 2020: 12). It is coupled with a remarkable receptivity towards various thematic influences and topics (Soler 2020: 2). The enthusiasm that science holds the potential to transcend strained relations is upheld by new voices keen to explore research cooperation and the role of science diplomacy (Střelcová, 2021: 5). However, this perspective is not aimed at expressing yet another appraisal of the European discussions. Instead, with references to Europe-based scholarly findings, it seeks to promote an outward-looking curiosity about the evolving intellectual circles and infrastructure affiliated with science diplomacy.

Science Diplomacy Review is an excellent example of how dedicated intellectual platforms are created and maintained for a continuous interaction on the broad scope of topics that researchers from across the globe are eager to discuss in a science diplomacy context. This perspective is aimed at exploring various avenues of how the Science Diplomacy Review as a study object and a

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testimony of its time might be considered for a more elaborate analysis in the future. Inspired by the latest thinking on histories of science and knowledge, including the circulation of knowledge, this perspective invites the reader to reflect on science diplomacy in two ways.

On the one hand, science diplomacy could be an object of study among those keen on examining the circulation of knowledge. Following this reasoning, Science Diplomacy Review could be considered as a promising object for future studies of how science diplomacy is articulated and certain ideas taken onboard by this journal that emanates from one of the "hotbeds of innovation and fundamental research" (Rüffin, 2020: 6). This suggestion is presented considering the journal's issues as elements of the overall publicly accessible intellectual infrastructure dedicated to science diplomacy. Taking inspiration primarily from the recent scholarly thinking on the histories of science and knowledge, science diplomacy sets in motion ideas and notions that are worth further consideration.

On the other hand, science diplomacy has certain agenda-setting properties. There is no single science diplomacy agenda. Selectivity generates heterogeneity. Here again, by learning primarily (but not exclusively) from the histories of science and knowledge, it is worth paying attention to the evolution of distinctive traits of science diplomacy discussions in various geographical locations and intellectual circles. A more nuanced elaboration is captured in the subsequent two sections of the perspective. The concluding part sums up the main points with a cautious invitation for future cross-fertilisation.

Public circulation of knowledge

The growing body of literature on science diplomacy shows that this area of scholarly and expert debates taps into various compartments of research. Historical case studies discussed during the science diplomacy consultations and captured in academic publications,[3] as well as attempts to trace the initial roots of practices of science diplomacy have encouraged to extend the horizon (The Royal Society, 2010: 1-2). It is a useful exploratory exercise in terms of making some limited attempts to find out what science diplomacy might learn from histories of knowledge and science. Such an outlook helps to situate science diplomacy within a broader spectrum of recent academically approached themes and phenomena. Eventually, it should contribute to discerning certain traits distinct to science diplomacy. There is room for honing what distinguishes science diplomacy from a plethora of other intellectual currents far beyond those tapped into in this article.

Public circulation of knowledge is a concept that guides elaboration captured by the subsequent paragraphs. The focus on the public character entails "that knowledge should be studied as a broad, societal phenomenon" with "social reach and relevance of knowledge under scrutiny" (Östling, 2020: 120). A broader resonance of certain knowledge and its interpretations is captured in this perspective. It is done by acknowledging that knowledge is not 'locationless', it is 'situated' (Elshakry 2020: 3; Fuller, 1992: 393; Sarasin 2020: 3; Traweek, 1992: 435) Polycentricity is embraced among the recent scoping of the research agenda of the history of knowledge (Bod, 2020;

Felten and von Oertzen, 2020: 10). Thus, the place, time and other contextual factors should be given due attention when attempting to understand the way knowledge travels, as well as evolves and transforms throughout these intellectual wanderings and structured analysis.

Science and technology studies pay attention to the entrepreneurial value of knowledge. The value of knowledge unfolds when it is linked to the right network of actors (Olesen, 2018: 39) or "knowing subjects in society" (Olesen, 2018: 44). Notably, these characteristics of knowledge are not conducive to an outright public character. The reason for bringing this fragment from science and technology studies into this perspective is to show concisely that public circulation of knowledge is not a catch-all term. To a varying degree, it applies to different domains that are characterised by a richness of public venues for encounters. There are types of knowledge that are more exposed to the public and those that maintain their valuable properties by being guarded against an outright or extensive public exposure. Science diplomacy is an ever more widely discussed topic among diverse research, policy-making and diplomatic compartments receptive to public exposure and exchanges of thoughts. Therefore, it might be a promising object for future study of the public circulation of knowledge.

Public circulation of knowledge brings better awareness about the multitude of factors that shape the overall understanding of science diplomacy in various parts of the world. Following the earlier mentioned characteristics of knowledge not being 'locationless', science diplomacy should not be considered as a monolithic body of knowledge. It gains traction worldwide but resonates differently across geographical and intellectual spaces. Science Diplomacy Review is a good example. It offers a platform for elaborating on dynamics evolving in certain places and spaces.

Public circulation of knowledge is not the only valuable notion capturing the motion of intellectual currents that helps to observe the ongoing evolution of science diplomacy. To hone the distinct characteristics and added value, science diplomacy advocates would benefit from an awareness of what arguments have guided earlier criticisms of the history of knowledge. Potential duplication of scholarly enquiry is voiced by referring to the history of knowledge touching upon "what historians of science and intellectual historians have been doing for the last two decades" (Östling and Heidenblad, 2020: 1). Such an awareness would help science diplomacy writers carve out their distinct niche.

Finally, the motion of intellectual currents should not be taken as a given. Silos and geographic compartmentalisation of certain intellectual exchanges and discussions are not a novelty. With another reference from the European studies, the lack of a more dynamic exchange between various centres of European studies has been voiced through references made to immobility (Weber and Tarlea, 2020). There is a lack of analysis on the way science diplomacy 'travels' or 'rests immobile' within certain local, national, regional or disciplinary or institutional contexts. A previously witnessed immobility in the European studies area should caution against assuming that all individuals discussing science diplomacy worldwide are talking about the same thing and have the same core framework as the initial point of departure. One of the best examples in this respect is the diversity of aspects picked up from the seminal report "New Frontiers in Science Diplomacy" (The Royal Society, 2010) in more recent publications. Science Diplomacy Review is a helpful facilitator for mapping the emerging heterogeneity. Its published articles offer an insight into what considerations guide various individuals and institutions interested in science diplomacy. The way science diplomacy sets in various local, national, regional, or disciplinary or institutional contexts is worth further consideration.

Science diplomacy agenda-setting during pandemic

Agenda-setting and its effects on what and where is being discussed in the science diplomacy context is also a promising topic for further enquiry. Historians of humanities pay attention to "Who forgets what, and why?; and Where does scholarly forgetting take place?", the role of "the inner circle of academia" in forgetting, defining what is relevant and what is not (Lamers, Van Hal and Clercx, 2020). This is a good reminder that science diplomacy agendas in various parts of the world and across diverse expert circles display certain selectivity towards topics chosen for elaboration.

Furthermore, scholars of the practice, who share with certain historians of science, interest in Bourdieu's work (Burke, 2020; Van Damme, 2020), elaborate on the localisation of professionals (Adler-Nissen et al., 2013: 117). A good point to keep in mind when exploring who shapes science diplomacy. Are these hyper-enculturated individuals who have been subject to a rigid cloning culture (Petersson and Sternudd, 2020) or 'curasumers' with individually tailored academic paths (Jeong and Kim, 2019: 14)? This question is aimed at giving further support to Sivertsen's neatly pinpointed elusiveness of an "impartial *and* well-informed spectator" (Sivertsen, 2019: 68). Obtained higher education, training and professional paths may leave a certain imprint on the way science diplomacy agenda is shaped in certain geographical or professional contexts and perceived by those keen on describing or commenting on this process.

Besides the considerations mentioned in the previous paragraph about the individual formative experiences, prioritisation on an institutional level of one theme over another may contribute even further to the development of distinct local understandings and meanings of science diplomacy. Researchers of the practice turn point out that academia and its outputs are shaped by a range of considerations spanning "from the office politics of departmental settings, to recruitment and promotion panels, to journal editorial decisions, to the arrangement and juxtaposition of panels at conferences, and citation practices" (Adler-Nissen et al., 2013: 160). To top up this complexity of the intellectual infrastructure, it is worth bringing into the discussion earlier observation that internationalisation directed towards the research performance at the universities has received a mixed reaction and varying degrees of responsiveness (Hokka, 2019). These complex processes reveal interactions that go way beyond mere statistical information on academic publications captured by the Web of Science, Scopus, ORCID or an Altmetric badge. All these earlier scholarly reflections are taken on board as cross-cutting trends that can leave an imprint on the future heterogeneity of science diplomacy. Keeping in mind this panoply of considerations, Science Diplomacy Review proves to be a promising point of departure for a more detailed study of the intricacies of knowledge generation and circulation, or stagnation of certain ideas grounded in science diplomacy. The journal embodies a specific agenda that the Forum for Indian Science Diplomacy supports and suggests as relevant to a broad international audience.

Experts interested in science diplomacy have an opportunity to learn from these considerations and episodes acknowledged in other relevant research fields and take a comprehensive look at their practices in intellectual encounters. To echo some earlier remarks contributed to the debate on science as practice and culture, "[r]eflexivity asks us to problematize the assumption that the analyst (author, self) stands in a disengaged relationship with the world (subjects, objects, scientists, things)." (Wooglar, 1992: 334) The motion or stagnation of certain ideas and research findings, chosen prioritisation of themes to be incorporated in the elaboration on science diplomacy are important items for understanding what type of science (even if a post-normal one (Blok, 2019) feeds into the three taxonomies or varieties of science diplomacy. Science diplomacy is not a mere subject of study. This is an invitation to look at the Science Diplomacy Review as a regular practice of science diplomacy.

Way forward

Science Diplomacy Review is a noteworthy component of the overall international intellectual infrastructure of science diplomacy. Its capacity to set a certain agenda of the overall topics prioritised in science diplomacy discussions deserves more attention in the future. The journal could be an interesting object of study from the perspective of the public circulation of knowledge on science diplomacy. Histories of knowledge and science, practice turn, science and technology studies, and European studies offer some valuable considerations for science diplomacy and those interested in advancing this field forward. It is worth reflecting on the mobility or stagnation of certain ideas related to science diplomacy as situated phenomena with local contexts and traits wherever it is discussed and as a relatively nascent field of scholarly enquiry experiencing a dynamic expansion.

The earlier elaborations on various factors that shape the way research findings are conveyed or stop at certain institutional, disciplinary, or geographic boundaries indicate that science diplomacy as an internationally discussed topic should not be considered as a monolithic and monotone thought pattern. The way science diplomacy is understood in certain contexts may vary. It opens a whole new area for further study.

Endnotes

1. Reference to the European studies stems from the author's prior academic training and on-going research related to this field, as well as recent engagement in the activities of the University Association for Contemporary European Studies (UACES).
2. Consult Šime (2020) for an elaboration on the role of three Horizon 2020 funded projects.

[3] Abbé José Correiada Serra, Portuguese botanist and the first Ambassador of Portugal to the United States, analysed within the framework of InsSciDE (2021) is a good example

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5th Science, Technology and Innovation Policy (STIP) 2021 and United Nations Multilateral Standard-Setting Bodies: A Perspective

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Introduction

As India approaches 75 years of its independence, it is only apt to introspect and reflect on existing science and technology policy. What has been STIP's impact, whether it was successful in contributing to the national development, what is missing and what remains to be done in the context of new and emerging technologies? Is India fully equipped to deal with global challenges and to what extent? What should be its science and technology strategy for the 21st century? United Nations multilateral standard-setting bodies have been playing an important role in setting international standards vis-a-vis new and emerging technologies. Has India been able to fully utilise the platform. From an international diplomacy perspective, which involves, protection of the country's political interests abroad, to the pursuit of digital interests in the field of new and emerging technologies, it has been a big transition? The global foreign policy agenda is mostly dominated by discussions on science and technology issues including data interests, internet governance, artificial intelligence, cybersecurity, block chain technology, robotics and so on. How do we, as a country fare on these issues? The STIP creates a much needed atmosphere for policy discourse. Hence it is only apt that India begins its 21st-century science and technological journey with introspection.

India's participation in international multilateral standard-setting bodies has been noteworthy. It is one of the longstanding members of the United Nations

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(UN) and its specialised agencies such as the International Telecommunication Union (ITU), Universal Postal Union and World Meteorological Organisation, etc. It has remained one of the most consistent donors for the UN system. India and the UN were, more or less born together, UN has completed 75 years of its inception in 2020, while India will be celebrating 75 years of its independence in 2022. India and the UN share a close and warm relationship. However, at the age of 75, it is only apt to ask, whether India's partnership with United Nations standard-setting bodies has been productive? To what extent? Have the technological aspirations been met? and what needs to be done? India's achievements in science and technology are noteworthy. Whether it is India's mission to the Moon and Mars, or the development of information communication technology, the deep socio-economic impacts were evident. India's success in the field of Science and Technology could be attributed to its initial investment in them. Modern India had always maintained a strong focus on the development and promotion of science and technology at the centre of its policy discourse. The 5th Science, Technology and Innovation Policy (STIP) seeks to take forward the same momentum.

In the current changing times, science and technology have emerged as a political and strategic tool. It exerts a strong influence on geopolitics and power relations among countries and their ability to innovate and support industrial growth affects their international stature. The 5th Draft Science Technology and Innovation Policy (STIP), is a great initiative as it seeks to provide tremendous support for the science and technology ecosystem within the country. It aims to nurture and reward individual initiative, local innovations and work done by larger academic, research and development community.

From a multilateral perspective, science and technology discussions dominate the United Nations agenda. A large number of meetings and discussions are conducted regularly, throughout the year, with participation from delegates and experts, in standards-setting agencies such as International Telecommunication Union (ITU), World Meteorological Organisation (WMO), World Intellectual Property Organisation (WIPO) and World Health Organisation (WHO). The international standards discussed in these bodies represents global consensus. They strive to cater to the emerging societal and market demands. Guided by United Nations core principles of transparency and openness, these organisations involve multistakeholder engagement during the global standard development process, relevant for long term and sustainable science and technology policy. For instance, during the ongoing 5G global standards negotiations, the specialised agency of the UN for ICT has done its best to engage different stakeholders including various market actors. The strength of global standards developed under the auspices of the UN is that they are transparent and consensus driven. Through participation in these bodies, in-house capacities and solutions could be developed, which can save time, money and expertise. One of the major benefits, however, is that they facilitate trade. International standards developed through these standard-setting agencies conform with principles of international trade. Countries and businesses have confidence while dealing with products and services created through them.

The international standards are developed by taking into consideration wide stakeholder's interests in a multi-stakeholder environment. It ensures views embodying diverse socio-economic interests are represented in the process. They enhance acceptability and support local legislation. In terms of geography, their reach is large. Their membership is comprised of large number of countries. The members are given equal opportunity to participate in the development of standards, they also get support for capacity building. They provide direct and indirect support for the implementation of domestic science and technology policy.

India has a huge domestic pool of resources and technical experts. It has tremendous capacity in Information Communication Technology, Space Sector and Pharmaceuticals. India's technology, research and management institutes such as IITs and IIMs are significantly contributing to research and innovation. For instance, during the negotiations on 5G International Standards, India's technology proposal on "Radio Interface" was accepted by ITU as a complete technology. The proposal was produced by several leading research institutions including IIT Madras. This is just one example; these capacities could be leveraged to facilitate greater interaction with United Nations multilateral standard-setting bodies. By collaborating in the field of science, research, expertise and innovation, India could support the domestic ecosystem. Through regular information sharing and exchange of resources, the standard-setting bodies could help in fulfilling India's national interest in science and technology.

The fourth industrial revolution is primarily led by new and emerging technologies. The diffusion of the physical and biological world characterised by the use of artificial intelligence, cloud computing, and the Internet of Things (IoT) has become critical for developing countries. An engagement with the international standard development process will enable the countries to stay informed about the latest technological trends and development. It will be useful to support policy goals and governments efforts and to gain access to public policy challenges, through regular feedback and insight. The international standard-setting agencies could exert a tremendous impact on socio-economic development by facilitating innovation and best practices.

In the rapidly changing global environment, STIP must strengthen domestic skills and capabilities by ensuring effective participation in the multilateral standard-setting bodies. It could promote the participation of National Universities, Research Institutes, and general academia. India's goals for self-independence and localisation requires striking the right balance. The promotion of international cooperation with these bodies must form the primary focus of the new STIP. An intergovernmental framework could be put in place which will coordinate nationally funded research at the regional and global level. It can initiate joint and collaborative research programs with multilateral standard-setting bodies, to produce internationally market-oriented product and services.

STIP could help in bridging the existing gap between technical experts, research, academia, and the market by simplifying existing rules and restrictions. India's participation in international standard-setting agencies is affected by bureaucratic indecision and delays. The movement of technical experts and their participation in international meetings are subjected to various kinds of travel restrictions. There is a need to revamp these age-old rules and regulations.

India could put in place an integrated approach to facilitate effective participation at international standard-setting agencies. By creating a robust research and innovation framework, it could ensure that scientific and technological decisions of strategic importance for the country, such as new and emerging technologies are handled urgently at the national level, by one agency, rather than multiple ministries and departments. It will help in avoiding duplication of work and waste of resources. The national authority should be able to share data across wide sectors and stakeholders. India must broaden the horizon of participation to include diverse stakeholders including small and medium enterprises, industry, and female researchers.

The constitution of the National STI Observatory, Technology Support Framework and Strategic Technology Board (STB), under the new STIP are great initiatives. It will provide the required environment for the growth of local entrepreneurs and businesses. The harmonised regulations set by international standard-setting bodies will help in promoting local products and commerce.

While India has been very active in international diplomatic negotiations and discourse within the UN, the participation of technical and domain experts in various Study and Focus groups is somewhat limited. These smaller groups in standard-setting agencies play a crucial role in terms of setting the roadmap of standardisation for a particular technology to framing those standards. The New STIP could focus on enhancing India's participation in these small study groups. For instance, several specialised agencies of the UN regularly constitute these groups and sub-groups to discuss standards and technology policy. International Telecommunication Union (ITU) maintains around 20 similar groups which are busy drawing different parameters of digital technologies.

The World Meteorological Organisation (WMO), a specialised agency of the United Nations for weather and climate issues, facilitates the exchange of weather information and data across the world and supports National Meteorological and Hydrological Services. It has constituted several small committees looking into various aspects of digital data and its impact on current governance structures. The observational stations gather data on weather, climate, and other related fields, it is used by the private sectors for providing different products and services. It's committees are looking into the parameters of global data regulatory mechanisms.

Similarly, the intersection of new and emerging technologies has a huge impact on intellectual property rights. The World Intellectual Property Organisation (WIPO) deals with worldwide trademark, industrial design, parameters for geographical indicators, patents, and copyright issues. It regularly set norms for international IP rules and global services. WIPO's services are widely used by major corporations, small and medium enterprises, universities, and research institutions. They provide support for innovation, branding, international protection for inventions and discoveries.

The International Union for Conservation of Nature (IUCN) is the world's largest and most diverse environmental network of countries, government agencies and international organisations. It works for the conservation of nature and the protection of ecological biodiversity. It enjoys observer status within the UN system. IUCN provides a framework for environmental policy and climate change negotiations and maintains the "Red List of Threatened Species" which has tremendous international trade and commerce implications. IUCN is evolving international regulatory framework for synthetic biology products, new plant breeding techniques, traditional knowledge and genetic resources. It is involved in drawing-up the new international legal instrument on areas of marine biodiversity beyond national jurisdictions. Therefore, it is only useful that India's science and technological policy promotes engagement with these standard-setting bodies.

The emerging global science and technology landscape will be determined by new and emerging technologies. International standards harmonising in these areas technology will become geopolitically very important in the future. International rules and technological standards will increasingly shape the contours of economic development and global growth.

Therefore, collaboration with these international standard-setting agencies has become a necessity. The sooner we realise this fact and take corrective action the better it is. Early participation will strengthen local capabilities. The goals of technological self-reliance and becoming a scientific superpower can be realised by facilitating enhanced interaction with them. There is a lot of hope and optimism from the new STIP. It must create avenues of participation by diplomatic negotiators alongside the technical experts. India's representation, in terms of the number of Indians employed in standard-setting institutions, is very low. Representation in top positions means that India's voice is heard more clearly, and it is able to pursue its interests deftly. Enhancing the representation is a strategic and political decision, and the new STIP must facilitate this.

The private sector is playing an increasingly important role in international standard-setting bodies. They are regularly participating in technical meetings and negotiations. As a member of these bodies, they exert considerable influence on evolving technological parameters. They are participating on an equal footing along with national technical experts and specialists. New STIP could facilitate participation from the private sector into these multilateral standard-setting bodies. Many Indian companies and business have a strong domestic presence. They have tremendous potential for growth; however, it remains untapped due to their lack of participation in multilateral standard-setting bodies.

India could emulate similar practice followed by other countries and promote the participation of the private sector. Their involvement at the early stages of standardisation will enhance their capacities. They will become market-ready, by increasing global competitiveness. Regionally, India enjoys a leadership position in the field of science, technology and innovation. Whether it is capacity in space, health and information communication or other sectors, its record is unmatched. The new STIP could support regional initiatives. It could support regional capacity building programmes and projects, facilitate the establishment of regional offices, Innovation Centres and Policy Labs in and around the neighbouring countries.

Additionally, India could also facilitate the launch of regional offices and innovation centres, sponsored by multilateral standard-setting agencies, within the country. The New STIP could support such initiatives. It will be helpful if international standard-setting bodies are integrated with the national science and technology ecosystem.

So far, India has been able to consistently increase its gross expenditure on research and development. The Global Innovation Index, 2020, has placed India within the top 50 countries. The recent National Artificial Intelligence Strategy indicates India's inclination to engage with the outer world more boldly. India is aggressively working towards establishing itself as a leader in new and emerging technologies. The new STIP by incorporating fresh approaches, and mechanisms has cleared the way for its global leadership. An enhanced engagement with United Nations standards-setting agencies will only strengthen the vision of 'Atmanirbhar Bharat' and 'New India', a country is fully aware of its roles and responsibilities in the emerging world order.

Standing on the Shoulders of Our Giants: Science Diplomacy for the Future Scientific Progress

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Archana Sharma

Introduction

Being an experimental physicist, my focus remains mainly on leveraging and creating a future heritage for physics: defined as a natural science based on experiments, measurements, and mathematical analysis to find quantitative physical laws for everything from the nanoworld of the microcosmos to the planets, solar systems, and galaxies that occupy the macrocosmos. The laws of nature can be used to predict the behaviour of the world and all kinds of machinery. Many of the everyday technological inventions that we now take for granted resulted from discoveries in physics. The basic laws in physics are universal, but physics in our time is such a vast field that many subfields are almost regarded as separate sciences.

Early Greeks established the first quantitative physical laws, such as Archimedes' descriptions of the principle of levers and the buoyancy of bodies in the water. By the 17th century, however, Galileo Galilei and later Issac Newton helped pioneer the use of mathematics as a fundamental tool in physics, which led to advances in describing the motion of heavenly bodies, the laws of gravity, and the three laws of motion. The laws of electricity, magnetism and electromechanical waves were developed in the 1800s by Faraday and Maxwell while many others contributed to our understanding of optics and thermodynamics. Modern physics can be said to have started around the turn of the 20th century, with the discovery of X-rays (Röntgen, 1895), radioactivity

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(Becquerel, 1896), the quantum hypothesis (Planck, 1900), relativity (Einstein, 1905), and atomic theory (Bohr, 1913).

Quantum mechanics (Heisenberg and Schrödinger), beginning in 1926, also gave scientists a better understanding of chemistry and solid-state physics, which in turn has led to new materials and better electronic and optical components. Nuclear and elementary particle physics have become important fields, and particle physics is now the basis for astrophysics and cosmology. As physics developed across the world, from the Greeks to other Europeans and Americans, Physics enjoyed an equal level of development and gradual advancement across India.

History of physics in India

The development of physics in India is not one that I would say has enjoyed a particularly linear projection, although there have been some staggering reappearances who have been determining factors in how India's physics history has been written. Following Indian philosophy, Maharishi Kanada is attributed to being the first to systematically develop a theory of atomism around 200 BCE, although some authors have allotted him an earlier era in the 6th century BCE.

To look at this timeline in a chronology would be chaotic, so I will be focusing instead on the people who have developed physics as we have come to understand it today in India. However, I must make a disclaimer that it is not possible to mention all notable contributors and their contributions. Hence, I will try to mention those that I believe are fundamental to our development.

Top Indian Physicists

In terms of developing modern physics in India, the prime figure we all come to know is C.V. Raman. Sir Chandrashekhar Venkat Raman is fondly remembered, among several other innovations, for his invention of the 'Raman Effect,' a unique phenomenon in the scattering of light, which earned him the Nobel Prize for Physics in 1930, the first Indian to win the prize, I must add. Raman was born a prodigy, finishing his schooling with a scholarship when he was thirteen and receiving a 'Gold Medal' in Physics from his Alma Mater, the University of Madras. Raman's innumerable contributions earned him other important recognitions like the Hughes Medal in 1930, the Bharat Ratna in 1954, and the Lenin Peace Prize in 1957. He was also elected as a Fellow of the Royal Society (FRS) in 1924 and was knighted in 1929. India celebrates National Science Day on 28th February, the day he discovered the Raman Effect, in his honour.

Also, fondly remembered is Satyendranath Bose, who made vital contributions to the field of Quantum Mechanics. Bose invented the 'Bose-Einstein Condensate' with Albert Einstein and the 'Boson' particle. His inventions led to the formation of the Large Hadron Collider and the experiments conducted in it. He studied in the Presidency College in Calcutta, the institution to some of our country's most known and respected scholars. Bose was conferred with the Padma Vibhushan in 1954 and was elected as a Fellow of the Royal Society (FRS).

Another significant contributor is Meghnad Saha, whom the world of science will remember as one of the most prominent astrophysicists to have ever existed. Saha was most notable for the 'Saha Concept' or the Saha ionisation equation, a concept including theories and quantum and statistical mechanics, which he developed in 1920. It is also called the Saha-Langmuir equation. Saha was also famous for his other notable scientific works and his contribution to building several scientific institutions like the Physics department in Allahabad University and the Saha Institute of Nuclear Physics in Calcutta. Saha was also a Fellow of the Royal Society (FRS).

The father of the Indian Nuclear Programme, Homi Jehangir Bhabha, is also a prominent figure. Dr. Bhabha started the Tata Institute of Fundamental Research and the Trombay Atomic Energy Establishment, which was renamed as Bhabha Atomic Research Centre (BARC). His contribution to nuclear physics is unfathomable. While we remember Dr. Bhabha for the Indian's nuclear power programme, the world remembers him more for creating the process of 'Bhabha Scattering,' an electron-positron scattering process. He, too, was a Fellow of the Royal Society and was awarded the Adams Prize in 1942 by the University of Cambridge and the Padma Bhushan in 1954.

In 1983, Subrahmanyam Chandrashekhar became another Indian to win a Nobel Prize in Physics. Like Saha, Subrahmanyam contributed to astrophysics and consequently created the 'Chandrashekhar Limit.' He also contributed to quantum theory on the hydrogen anion, radiative transfers, the theory of white dwarfs, and stellar dynamics. Subrahmanyam earned the Adams Prize in 1948, the Royal Medal in 1962, the Copley medal in 1968, the National Medal of Science in 1966, and the Heineman Prize in 1974. He was conferred with the Padma Vibhushan in 1968 and was also the Fellow of the Royal Society. Perhaps he cheated the gene pool by getting the best because C.V. Raman was his paternal uncle.

As the times changed, the contributions of Physicists equally morphed across other necessary aspects, building a network of mega-science that continues to contribute to other important things today. That is why the work of Vikram Ambalal Sarabhai is very crucial in discussions. Vikram is known as the father of India's space programme, being one of the pilots of the Indian Space Research Organization (ISRO). He was awarded the Padma Bhushan in 1966 and the Padma Vibhushan posthumously in 1972.

We also have Gopalasamudram Narayana Iyer Ramachandran, who created the 'Ramachandran Plot.' He did his research work in X-ray microscope and crystal physics during his stint as the Head of Department at Madras University. He did his doctoral studies under the guidance of C.V. Raman. He founded the Molecular Biophysics Unit at the Indian Institute of Science in Bengaluru.

Then we have had Jayant Vishnu Narlikar, Indian astrophysicist, who, alongside Sir Fred Hoyle, developed the Hoyle-Narlikar Theory, a principal in gravitational studies. Harish Chandra, is known for the Representation Theory, while Sandip Chakrabarti, is well-known for his works in astrophysics and planetary motions. There are so many other vital contributors whom I am unable to mention in this short essay.

Merging India's physics development with our present

As India moved into a post-colonial phase, the *Tryst with Destiny* address was delivered on the Red Fort in Delhi on 15 August 1947. Jawaharlal Nehru was a strong proponent of modern ideas and valued science, the most. It was perhaps his cultural upbringing that had a deep impact on him. Nehru studied science at the Cambridge University, and he saw India from the perspective of the European Enlightenment. It was Nehru's vision to promote science as most of the scientific stalwarts in the early years of independent India saw science as a civilisational tool. The approach was empathetic and forward-looking, yet it was somehow draped in the colonial sense of science as a liberating discipline, and the development of the native could only be possible in the domain of science. The past was frowned upon, and as one can see in retrospect, there was a desperate urge to modernise India. Invariably, to advance better and more sophisticated scientific understanding in India, it was the collaborative efforts achieved with physicists that gave birth to the scientific revolution which India has built wildly on.

Of course, the journey had its tense moments where we struggled to collaborate, but they were nonetheless important. Saha, known for his Ionisation Equation, opposed several policies of Nehru government on science and technology development. He had arguments with Kriplani, Radhakrishnan, and Nehru. These were unapologetic and unashamed questions in the open house of the Indian parliament. He often had heated discussions with his parliamentary colleagues, especially Nehru. In a letter to Jivatram Bhagwandas Kriplani, Nehru wrote "It is unfortunate, that Professor Saha's letter has been written in a spirit which is far from scientific or dispassionate." Saha, an acclaimed physicist, was nominated for the Nobel Prize in Physics six times between 1930 and 1955. Nevertheless, the political opposition invariably built a robust collaborative environment that has allowed several scientists, particularly physicists, to thrive.

While I must revert once again to mentioning that I am not denying due credit to people like Birbal Sahni, P.C. Mahalanobis, Obaid Siddiqui, or M.S. Swaminathan and Shanti Swaroop Bhatnagar who greatly contributed to the architecture of modern India. But my emphasis is on the fact that physicists like Homi Bhabha, C. V. Raman, Meghnad Saha, Vikram Sarabhai, and S. N. Bose had a greater academic depth and traction with Indian scientific community and the political leadership. People like Saha became member of the Indian parliament in the 1950s.

As I have subtly hinted, what is perhaps, the essential catalyst in all this is the chain of scientific collaborations across different generations of physicists. Look at how, for instance, C.V. Raman has been able to help other physicists in their development. All of these are now the bedrock of the future of physics in modern India. Ideally, many people would have separated our history into the pre-colonial era, colonial era, and our present era. Still, our physicists have thrived across boards, and we will do better to look at how we can connect the past to the future. The role played by these figures led to an essential aspect of developing mega-science, which we must all continue to pay attention to as science diplomacy. It is through all these works, these efforts, that we now begin to take unprecedented steps in modern mega-science in India.

If we look at monumental projects like CERN in which India became an associate member in 2017, we will see that the fruits of passion and development planted by the physicists of past generations are now germinating in collaboration, in multinational science project for all of humanity.[1] As Dr. Fabiola Gianotti mentioned in 2019 in her capacity as

CERN Director-General, "India is one of the biggest contributors to CERN, being involved in various programmes like computing, power supply systems, hi-tech components, and high precision mechanics." India, however, could leverage a major win-win through new collaborations, what then is the future for India?

Why science diplomacy is important

Science diplomacy is not new, but it is more important than ever due to the scientific dimension of the current global challenges. No nation-state can tackle any of these challenges alone, thus their foreign policy needs to integrate new tools for a world of increasing scientific and technical complexity. Unlike in the 19thcentury when world peace depended on who had the most force, the future of global peace hinges on the level of diplomatic relations between countries, and how scientific advancements are now tied with cross-border knowledge sharing. This was why, unlike in the past, when each country and its scientists guarded their knowledge fiercely, and only opened it to allies, the development of the particle accelerator saw multilateral knowledge sharing leading to the advancement of physics in ways which the world had never known it. It opened the world of science to mega-science without borders.

Understanding mega-science

Historians Lillian Hoddeson, Catherine Westfall, and Adrienne Kolb introduced the term ''Mega-science'' to characterise experiments that are of an unprecedented scale in terms of equipment, experimental groups, and budgets; and that involves 'strings.'[2] By strings, the authors were not referring to the controversial ''string theory''; they meant that the experiments are not staged once and then disappear but continue to have an evolving presence in an experimental program (a ''string'' of experiments), and sometimes even no clear-cut end. The experiment, so to speak, becomes a long-term fixture of the institutional stage itself.

The operational dimension of mega-science means that it is not just a partnership between two scientists but also multiple researchers across different locations. The multilayered level of knowledge sharing also implies an openness between governments to encourage multilateral developments. While the growth and advancement of mega-science have been sporadic across several continents, an economic visit to the importance of physics-based mega-science is essential.

Mega-science and science diplomacy for the global development

While there are several examples, a very crucial example is the declaration of the Antarctic Treaty. The Antarctic treaty is a product of sustained science diplomacy, which has merged with mega-science. In the 1950s, scientists working on developing mega-science projects saw the potential hazard of ignoring the Antarctica continent. Although inhabited, scientists were worried that in the future, it may become the home to newly discovered resources, or may be used as testing sites for nuclear energy projects. To prevent a future escalation of conflicts, diplomatic scientists pressured governments to consider a treaty that would prevent any such conflict in the future.

According to the U.S department of state, fortunately, international scientific associations were able to work out arrangements for effective cooperation.[3]

In 1956 and 1957, American meteorologists "wintered over" at the Soviet post Mirny, while Soviet meteorologists "wintered over" at Little America. These cooperative activities culminated in the International Geophysical Year of 1957-1958 (IGY), a joint scientific effort by 12 nations -- Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, the United Kingdom, and the United States - to conduct studies of the Earth and its cosmic environment.

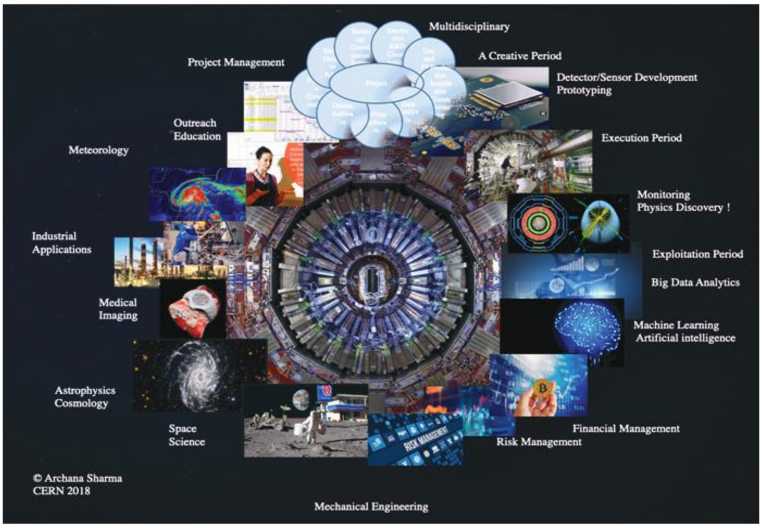
The AAAS Centre for Science Diplomacy also informs us that Scientific research and innovation are among the most potent forces driving economic development and social change.[4] Yet while scientific research facilities become larger, more complex, and require more resources, funding for scientific research is often not increasing in many countries even as the timescale for projects. Faced with these intimidating technical and financial challenges, science can either abandon its exploratory spirit or adapt by fostering greater coordination and collaboration on a global scale. The need for governments to put attention to mega-science and science diplomacy has been well exemplified in Europe.

In 2019, the Centre for Economics and Business Research (CEBR) carried out an analysis to measure physics's impact on the modern economy.[5] CEBR discovered that physics makes a net contribution to the European economy of at least €1.45 trillion per year and suggests that physics-based sectors are more resilient than the broader economy. Analysing data available to the public domain, CEBR found out that between 2011 to 2016 in 28 European countries, physics-based goods and services contributed an average of 44 per cent of all exports. According to CEBR, the top industries are shared as follows: Germany 29 per cent, the UK 14.2 per cent, France 12.9 per cent and Italy 10.4 per cent. *An important takeaway from this report is that European countries invest at least €22 billion every year to keep this going.* Some of this funding comes from the government. And this once again proves the importance of science diplomacy.

The development of physics and mega-science through science diplomacy at an international level will foster global peace and encourage economic advancements. Consequently, governments need to enforce necessary science diplomacy focused plan, not just for their self-interests but also for global peace. This development has become very necessary and will continue to become important if the world continues to seek sustainable science solutions. Governments that, however, decide to hoard information and prevent collaboration will suffer from isolation. Global peace will no longer be dependent on might but cooperation. And this collaboration will be led by science, scientists, and scientific diplomacy.

Mega-Science Diplomacy

As an experimental scientist working on large projects envisioning the future of my field, may I bring your attention to monumental mega-science projects such as those at the High Luminosity Large Hadron Collider, Future Circular Collider at CERN; Facility for Antiproton and Ion Research (FAIR); India-based Neutrino Observatory (INO); International Thermonuclear Experimental Reactor (ITER); Laser Interferometer Gravitational-Wave Observatory' (LIGO); Thirty Meter Telescope (TMT) and Square Kilometre Array (SKA). These projects do not only serve as a reminder of where we have been but also where we could be. They are a souvenir of the greatness which Indian scientists, particularly physicists, have



achieved, and they will be here to usher in the next generation of Indian scientific leaders.[6]

Through steadfast collaboration, the contribution, and the commitment of scientists before us, we will continue to advance as a nation through time and with the aid of science to break more grounds in research and development. The potential which science holds in India is not only to the merits of researchers, nor just for winning more Nobel prizes but also to develop the economy of India. Megasciences currently supports the European economy with at least €1.45 trillion per year. India is working towards this, and it is essential, nonetheless, to remind ourselves why we should focus on our objectives.

We have the works and efforts of great people like C.V. Raman to guide us, and we can only continue to work earnestly towards building our future. Our path is laid before us, and now it is left for us to accelerate science and science diplomacy towards consolidating its impact in our society. The importance of diplomacy in arriving at agreements on mega-science projects and the dire need for continued science diplomacy for successful execution during the whole life of the project will be explored in detail in a future article with a focus on the exemplary governance of CERN.

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OBITUARY

We are deeply saddened by the demise of Prof. M. Anandakrishnan on May 29, 2021. In January-February, 1978, I was a member of the Indian delegation for the Preparatory Committee for the United Nations Conference on Science and Technology for Development which met in Geneva. Our small 3-member team was led by Dr. Arcot Ramachandran, the dynamic Secretary of the newly set up (in 1971) Department of Science and Technology (DST) of the Government of India. The team included Dr. M. Anandakrishnan, then the first Indian Science Counsellor in Washington (since 1974). The creation of the post of Indian Science Counsellor in the USA was one of the many initiatives taken by the Department. Dr. Ananadakrishnan was closely involved in the work of the UN Commission on Science and Technology for Development in New York, covering it from Washington. Since, Dr. Ramachandran was the Chairman of the Preparatory Committee, the two of us had to manage the Indian participation in the meeting. This was indeed a great experience for a young diplomat to work with these two experienced scientists, and I benefited a lot from this experience. Later Dr. Ramachandran and Dr. Anandakrishnan went on to take senior positions in the UN system, where they made important contributions as head of UN Habitat (in Nairobi) and in UNCSTD respectively.

We sincerely thank Dr. Sadhna Relia, *GDC Fellow, Global Development Centre, New Delhi* for sharing the paper presented by Prof. Anandakrishnan at the International Workshop on Science and Technology Diplomacy for Developing Countries in Tehran, Islamic Republic of Iran during May 13-16, 2012.

- Bhaskar Balakrishnan, Former Ambassador of India and Science Diplomacy Fellow, RIS.

PERSPECTIVE

Science Diplomacy Beyond Politics

M. Anandakrishnan*

(12 July 1928 - 29 May 2021)

M. Anandakrishnan

There is a universal recognition that Science and Technology (S&T) are key instruments for national social and economic development and for strengthening the competitive capabilities of institutions and organizations in the country as well as for protecting and enlarging the strategic interests. No matter at what stage of development a country is, it has to devote serious attempts in two fronts, one to build up its endogenous S&T capabilities in areas of priorities and two, to acquire the needed S&T knowledge and resources for its critical and vital needs (CVN) from external sources by one means or the other.

The acquisition of S&T knowledge and resources from external sources might be straight forward in many cases while there could be many imponderables and conditionalities to be fulfilled in many CVN technologies. Herein is the value of understanding the scope of Science Diplomacy (SD).

By and large the use of S&T capabilities is for fulfilling the short and long term CVNs. At the same time such capabilities are of immense value in participating bilateral and multilateral forums so as to protect the national strategic interests, especially in the twenty first century context where transformations in S&T domains are taking place at un incredible speed.

The Scope

There is no standard definition of Science Diplomacy. Over the years, the evolution of national and international collaborative initiatives has led to commonly used

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Paper presented at the International Workshop on Science and Technology Diplomacy for Developing Countries, Tehran, Islamic Republic of Iran, 13-16 May 2012.

definition. Science diplomacy is the use of scientific collaborations among nations to address the common problems facing 21st century humanity and to build constructive international partnerships. Many experts and groups use a variety of definitions for science diplomacy. There are many ways that scientists can contribute to this process (Hormats, 2012). It has, nonetheless, become an umbrella term to describe any number of formal or informal technical, research-based, academic or engineering exchanges. Science as a tool for diplomacy has been in employment for several decades and among very many countries around the world. Some of the notable achievements through SD during the last century are:

Creation of the International Council of Scientific Unions (ICSU), in 1931 through partnerships with international science unions and national science members: The ICSU focuses resources and tools towards the further development of scientific solutions to the world's challenges such as climate change, sustainable development, polar research and the universality of science.

Establishment of the European Organization for Nuclear Research (CERN): It is run by 20 European member states, with involvement from many non-European countries. Scientists from some 608 institutes and universities around the world use CERN's facilities.

Other well-known examples are the Space Station, the Pugwash Conferences, the Arctic

Council, the Antarctica Treaty, the Kyoto Protocol, Ozone Hole Reduction, Control of Communicable Diseases and so on. There have been similar collaborative efforts in improving agricultural productivity, and protection of environment.

These are outstanding examples of SD where the scientists and technologists played far more effective and influential role than the political system. However the practice of SD may require the explicit or implicit consent of the ruling political power. Even so, there are many notable examples of scientists establishing fruitful contacts and collaboration even in the face of political hostility. The availability of internet technologies facilities such collaborations on a wider canvass.

There are innumerable instances of SD having produced lasting benefits to the humanity. The Twenty First Century will certainly witness unprecedented developments in the variety of scientific discoveries and technological innovations at unimaginable speed. The practice of science is increasingly expanding from individuals to groups, from single disciplines to interdisciplinary, and from a national to an international scope. The Organisation for Economic Co-operation and Development reported that from 1985 to 2007, the number of scientific articles published by a single author decreased by 45 per cent. During that same period, the number of scientific articles published with domestic co-authorship increased by 136 per cent, and those with international co-authorship increased by 409 per cent. The same trend holds for patents. Science collaboration is exciting because it takes advantage of expertise that exists around the country and around the globe. American researchers, innovators, and institutions, as well as their foreign counterparts, benefit through these international collaborations. Governments that restrict the flow of scientific expertise and data will find themselves isolated, cut off from the global networks that drive scientific and economic innovation. (Hormats, 2012)

Some of these will be protected to gain economic and political advantages. It is the responsibility of the S&T community to facilitate unlocking these knowledge and resources for the wider benefit of humanity. The United Nation System has played very proactive role in the past facilitating the diffusion and adaptation of scientific knowledge and technological practices in very many domains through the UN specialized agencies such as UNESCO, UNIDO, FAO, WHO, WIPO and so on. Their task will be even more challenging in the future and would require promotion of SD on a wider scale.

The institutional frame work

The practice of effective SD is not an occasional endeavour. It requires a carefully constructed organizational framework and availability of sufficient number of practitioners of SD with adequate S&T knowledge and appropriate diplomatic skill. These include creation of positions of S&T Attaches in the major countries of interest (not just in a few developed countries); the national S&T academies to establish a unit dealing with SD; the S&T departments of the government to support such units of the Academies as well as selected university departments in the country to undertake assigned policy analysis and training functions and positive framework for binational/ international agreements and treaties.

In this context, the example of the American Association for the Advancement of Science (AAAS) may be mentioned. AAAS established its Center for Science Diplomacy on July 15, 2008. The Center is guided by the over-arching goal of using science to build bridges between countries and to promote scientific cooperation as an essential element of foreign policy. The AAAS Center for Science Diplomacy focuses on three approaches to its core activities:

Inspirational**:** Raising the profile of science diplomacy by convening and building a community of stakeholders for science diplomacy activities and initiatives;

Operational**:** Initiating exchanges, visits, and bilateral activities to put science diplomacy into action; and

Intellectual**:** Creating a foundation of research and analysis to identify and define key issues in science diplomacy and to develop science diplomacy strategies.

In particular, the AAAS Center for Science Diplomacy is interested in identifying opportunites for science diplomacy to serve as a catalyst between societies where official relationships might be limited and to strengthen civil society interactions through partnerships in science and technology.

US approach to science diplomacy

Science diplomacy is a central component of America's twenty-first century statecraft agenda. The United States increasingly recognizes the vital role science and technology can play in addressing major challenges, such as making their economy more competitive, tackling global health issues, and dealing with climate change. Innovation policy is part of our science diplomacy engagement. More than ever before, modern economies are rooted in science and technology. It is estimated that

America's knowledge-based industries represent 40 per cent of their economic growth and 60 per cent of their exports. Sustaining a vibrant knowledge-based economy, as well as a strong commitment to educational excellence and advanced research, provides an opportunity for our citizens to prosper and enjoy upward mobility. America attracts people from all over the world—scientists, engineers, inventors, and entrepreneurs—who want the opportunity to participate in, and contribute to, our innovation economy.

At the same time, their bilateral and multilateral dialogues support science, technology, and innovation abroad by promoting improved education; research and development funding; good governance and transparent regulatory policies; markets that are open and competitive; and policies that allow researchers and companies to succeed, and, if they fail, to have the opportunity to try again. They advocate for governments to embrace and enforce an intellectual property system that allows innovators to reap the benefits of their ideas and also rewards their risk taking.

Conclusion

The idea of using science to pursue diplomatic goals is rapidly gaining popularity. Scientific collaborations can build trust and facilitate progress in vary many critical and vital areas of national and international. Many different tools needed to ensure that science diplomacy operates both effectively and fairly. They are emerging in the form of special groups in national and international scientific organizations and the UN Agencies besides the binational treaties and agreements. In these various efforts the scientific and technological community must ensure their independence of advice not conditioned by the political environment at a given point of time.

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REPORT REVIEW

Technology & Innovation Report 2021 Catching the Technological Wave - Innovation with Equity

Kapil Patil*

Kapil Patil

Technological change has historically brought with it immense socio-economic gains and transformed the human society in innumerable ways. Technology has not only been an essential constituent of economic growth and development but also an important marker of societal progress. Starting from the first industrial revolution in the eighteenth century, successive industrial waves opened-up new economic opportunities afforded by new technologies and transformed human lives via new technological solutions. The benefits of technological progress, however, also resulted in the creation of economic inequalities as technological progress was mostly concentrated in countries of the global north many excluded a large number of countries from the southern hemisphere. Over time, every new technological wave served to deepen the divide between the so-called technological 'haves' and 'have nots'. For the technological 'haves', the scientific progress served to enhance industrial productivity, trade, and economic well-being whereas for the large number of 'have nots', the technological change involved an arduous process of catch-up, and intense learning and technological capability building efforts. In recent decades, the rapid industrialisation in many developing countries has led to the emergence of a global middle class. However, the chronic persistence of poverty in many regions of the world, especially the low and

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middle-income countries (LMICs) poses a serious challenge for creating an equitable international economic order.

A crisis like the ongoing COVID-19 pandemic has amplified such gaps as many countries reported the annulment of gains on SDGs like poverty alleviation. As the world is transitioning to yet another industrial wave popularly called the 'fourth industrial revolution' or 'industry 4.0', the concerns surrounding new technologies to deepen the existing economic inequalities or creating new ones have once again become critical. Enabled by convergences in digitalisation, connectivity, and the rise of frontier technologies like artificial intelligence, robotics, energy storage systems, the internet of things (IoT), additive engineering, etc., the fourth industrial revolution promises to significantly increase productivity, trade, and economic development. The embrace of industry 4.0 technologies, however, can also have serious downsides if they outpace the society's ability to adapt since many low and middle-income countries (LMICs) continue to operate far away from the technological frontier. The lack of access and adoption to digital solutions severely affected the ability of several under-developed countries to deal with the COVID-19 pandemic. Consequently, the new technological revolution, if left unregulated, could pose a serious challenge for creating an equitable international economic order, and ensuring the social well-being of large sections of the global population. In this context, the 2021 Technology and Innovation Report, "Catching Technological Waves: Innovation with Equity", brought out by the United Nations Conference on Trade and Development (UNCTAD) marks a timely effort towards addressing existing inequalities between and within the countries arising from technological transformation[1]. The report mainly contends that frontier technologies hold immense potential to transition towards sustainable development and that it is important to bear in mind that such transformation depends on the ability of countries to match the pace of rapid technological change and to adapt and steer the growth of frontier technologies. The five thematic chapters of the report deal with key issues associated with new technologies such as drivers of technological change, impact on labour markets, economic risks, and opportunities, bridging innovation with equity, and policy reforms to foster an equitable future.

Catching Technology Waves

The report begins by highlighting that different technological waves from 1800 to 2002 have increased the contribution of between-country economic inequality to global inequality from 28 per cent to 85 per cent. Furthermore, the widening 'between country' and 'within country' inequalities resulted in the intergenerational transmission of inequalities in many countries. Along with the dire socio-economic conditions of citizens in many LMICs, the technological advancements have adversely affected the environment, abetted military conflicts, which in turn stifled social progress. As the world is encountering yet another technological revolution, the report highlights that new technologies, products, industries, infrastructure, and institutions created by new technological wave risks intensifying existing economic inequalities or create new ones by leaving behind many poor and catching-up countries. Drawing insights from past experiences, the report thus cautions that "new technologies can have serious downsides if they fail to outpace a society's ability to adapt" and calls for policymakers in both developed and developing countries to prevent new technologies from deepening existing divides.

The report describes frontier technologies as a group of new technologies that take advantage of digitalization and connectivity to combine and multiply their impacts. Marking the emergence of a new 'technological revolution', the eleven frontier technologies identified in the report such as artificial intelligence (AI), the Internet of things (IoT), big data, blockchain, 5G, 3D-printing, robotics, drones, gene editing, nanotechnology and solar photovoltaic (Solar PV) have immense potential for transforming production and business processes. Together, these technologies represent a $350-billion market, which could grow over $3.2 trillion by 2025. However, only a handful of countries like the United States and China produce most frontier technology-related products and that all countries need to prepare for adopting and producing these technologies. To assess national capabilities to equitably use, adapt and adopt these technologies, the report has developed a 'readiness index' comprising five building blocks namely ICT deployment, skills, R&D activity, industry activity and access to finance.

Since industries in much of the global south largely operate away from the technological frontier, there is a need to fast-track the adoption of these technologies in catching up and in the least ready regions of sub-Saharan Africa. Incidentally, the report identifies India as an 'outperformer' in terms of its technology readiness. India's out performance in the adoption and development of frontier technologies arises not so much from its R&D expenditure which remains far lower but from the abundant supply of highly skilled and relatively inexpensive human resources. For other developing countries, the report cautions that the failure to match the pace of technological adaptation could only accentuate initial inequalities, and in the long run would either overwhelm or leave behind poor communities and countries. Much will therefore depend on whether developing and least developing countries are catching up, forging ahead, or falling behind. The progress of these countries in the new technological revolution would be shaped by their national policies and by their involvement in international trade.

Technologies affecting inequalities

The report attempts to measure the impact of new technologies on economic inequalities by focussing on their impact on jobs, wages, and profits. A major concern surrounding the use of frontier technologies like AI and robotics relates to the potential reduction in employment since these technologies would automate many routine non-cognitive jobs as well as tasks. Historically each technological wave has destroyed several existing jobs but also created several new ones. The industry 4.0 technologies however are perceived to be structurally distinct as their use would result in large-scale automation of several existing jobs without creating new ones. Considering the dynamics of technological change in many developing countries, the report rightly highlights that adoption of AI and robotics would be contingent upon a range of technological and economic factors and as such the estimates of job losses based on technological feasibility would not necessarily translate into actual automation of jobs.

In the context of automation, the report rightly infers that "much will depend on relative prices", and that technological feasibility and supply of capital alone would not result in the substitution of labour in many industries. Another important concern for developing countries in the wake of industry 4.0 pertains to the reshoring of industrial production by multinational firms as new technologies reduce incentives for these firms to offshore production to low-cost destinations. The report examines the feasibility of reshoring holistically and identifies various factors that shape firms' decision to adopt industry 4.0 technologies. These mainly include factors such as low wages in developing countries, low technological and innovation capabilities, poor adoption of new technologies, and weak financing mechanisms, etc. Instead of being overly worried about the spectre of job losses, the report makes a strong case for countries to "prepare for a period of deep and rapid technological change".

To enable the rapid transition towards industry 4.0, the report calls for setting strategic directions and national plans for research and innovation. Among other, it calls for national innovation policies to align with industrial policies and harness frontier technologies for achieving progress on sustainable development goals (SDGs) like poverty reduction, sustainable livelihoods, food security and smart agriculture, and employment generation, etc. More importantly, it argues that anticipating the demand placed by new technologies on labour markets and promotion of digital skill development programmes for students and the workforce constitute key priorities for policymakers in developing countries and to close the digital divides. Similarly, upholding the human-centric approach to technological adoption, the report calls for enacting a slew of social safety measures for workers who would lose their jobs and are unlikely to trained or retrained. In the context of frontier technologies, the idea of 'automation tax' has gained much traction. Such ideas however would only put pressure on firms in developing countries to resist technological change and in turn, lose out on opportunities for economic progress.

Innovation with equity

Lastly, to promote equitable growth and adoption of frontier technologies, the report underlines the need to balance innovation with equity. Arguing that technologies have historically been a source of inequalities, the report notes that it is important to remove the systemic bias and discriminations inherent in technological development. For instance, technological effort across the countries is predominantly male-dominated and most technologies are created by firms in the Global North. Such technologies poorly serve the needs of developing countries and crowd out innovations that might be beneficial for the poor and marginalised sections of their society. To overcome such challenges, the report appeals to the governments to launch policy measures that are context-specific, all-encompassing, and support sustainable development goals. The need for developing countries to pursue science, technology, and innovation policies appropriate to their development stage and economic, social, and environmental conditions are therefore far more urgent than ever. Through focussed policy interventions, the poor and catching-up economies of the southern world can improve strengthen their innovation system and pursue all-round development.

Priorities for international cooperation

Towards achieving these goals, the report strongly calls for fostering international cooperation to build innovation capacities in developing countries and facilitate technology transfer and undertake technological foresight studies. Furthermore, it calls for addressing gender gaps in digital policy formulation and implementation. A key takeaway from the report is that it is possible to balance the opportunities and risks associated with frontier technologies through appropriate policy interventions. Based on strong evidence, the policy interventions can help developing countries to overcome many structural limitations and rapidly forge ahead in the new technological revolution. Civil society has an abiding role to play in this regard in terms of orienting technological change towards sustainable and inclusive development. In particular, the use of frugal approaches can be particularly valuable in terms of crafting efficient responses to innovation needs and making design and usage of frontier technologies to support sustainable societal goals. The findings of this report are particularly valuable for countries like India, which is shown as one of the 'overperformer' in frontier technologies given its low levels of per capita gross domestic products (GDP). India must leverage its early gains to build competitive advantages in frontier technology-based products and services. India clearly cannot afford to miss the bus on the fourth industrial revolution and should launch all possible interventions to foster the transition towards a sustainable growth pathway.

Endnote

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Using Future Scenarios of Science Diplomacy for Addressing Global Challenges

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Elke Dall

Mitchell Young

The effective handling of global challenges requires that we consider the position and role of science diplomacy within various possible future structuring of the world order. The EU-funded project, "Using Science in/for Diplomacy for Addressing Global Challenges" (S4D4C), organised several events to discuss the future of science diplomacy. Networking events resulted in policy briefs (Melchor et al., 2020) and focus groups were used to develop the transversal analysis (Young et al., 2020a) of our case studies (Young, Flink, and Dall, 2020b). In this context, we engaged also in scenario-based forecasting to assist in our analysis. Scenarios are 'stories' illustrating critical aspects of possible futures and have a long history of being used in foresight processes (Poli, 2018; Wright et al., 2011).

In this review, we would like to present the approach of using scenarios to spark discussions among a group of science diplomacy practitioners and academics about the future of science diplomacy and to explore evolving stakeholder relationships and governance trends that follow from our case study findings. The use of scenarios represents for us a mechanism to think about the next era of science diplomacy. The COVID-19 crisis compels us to envision societal change and to consider alternative futures that seemed previously unlikely (Nye, 2020). In that way, it also urges us to reimagine approaches to addressing global challenges through science diplomacy.

Scenarios for science diplomacy addressing global challenges

For the focus group in Budapest (Hungary) in November

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2019, i.e., well before COVID-19 had come to dominate our lives, we developed four future scenarios for science diplomacy. The scenarios were designed to capture what we considered, based on extensive case study work and the outcome of several large stakeholder meetings in Madrid and Berlin (Young et al., 2020a; Young, Flink, and Dall, 2020b; Melchor et al., 2020), to be the key parameters and trajectories that would impact on science diplomacy over the next decade. First, the role, importance, and positioning of science vis-à-vis policymaking was considered on a continuum from being deeply integrated to being politicized, instrumentalised and marginalised. In the classic typology of science diplomacy (Royal Society, 2010) this connects with both 'science in diplomacy' and 'science for diplomacy' and relates to the uptake and use of science in foreign relations activities. Second, we wanted to bring in the growing geopolitical emphasis on national interests and the potentially emerging bipolar global order, and to contrast that with transnational interests and global goods, drawing in this way on the so-called pragmatic perspective on science diplomacy (Gluckman et al., 2017). This also captures the elements of multilateralism, bilateralism, and the role of International Organisations. Finally, to round out the scenarios, we brought in the more general tension between competition and cooperation that pervades science diplomacy's context and practices. Mixing these various ingredients, we came up with the following four scenarios to present:

"All-in" Multi-lateral world order

As global challenges become increasingly urgent, countries begin to cooperate more deeply and devote significant resources to resolve them, accepting that this can even mean (at least partially) overriding the national interest. The world becomes more multilateral and the power of international organisations as sites for addressing global challenges is elevated. Science takes precedence over political interests and ideologies and is open for everyone.

Reluctant but principled approach

Countries agree in principle on the need to resolve global challenges, but national priorities and interests still play a major role. Bilateral negotiations are predominantly complemented by some multilateral efforts. Science is seen to have a supporting role but is subservient to politics. Science is open only when it is sure that there is no competitive advantage to be gained from restricting it. While politicians seek accurate scientific advice, they do not consider it decisive in policymaking.

"Lip service" model

Countries still talk about the importance of global challenges but provide few resources and little diplomatic effort. In negotiations, the national interest is dominant. Science is seen as an instrument for countries to gain competitive advantage, both in economic terms and in ideological ones. Politicians pick and choose their science and undermine it when it does not suit their purposes.

Conflict and contraction

Countries are increasingly isolated and in conflict with one another. Global challenges become litmus tests for allies, and countries divide and align themselves in a cold-war-like manner between the major powers. Science is highly politicized and not shared except with countries that share values and alliances.

Reception of the scenarios at the event

The scenarios proved to be an effective way to provide crisp, even a bit provocative, starters for a discussion about the future of science diplomacy. They were discussed in depth at a side-event at the World Science Forum in Budapest (Hungary) in November 2019 with a small group of senior experts selected to represent different areas such as social as well as natural sciences, international organisations as well as national ones, experts focused on Europe as well as globally, junior as well as senior profiles, science diplomats with a focus on the scientific as well as scientific management and international relations, female and male participants, including selected members of the research team.

The idea that anyone scenario was either currently predominant or likely to become so was quickly quashed. It was pointed out that we currently occupy all of them, depending on the perspective we come from: geographical, issue area or sector, and actor type. Also, the dominant role of the nation-state in framing the scenarios was questioned as international organisations, networks and social movements across borders have become more prominent.

Furthermore, thinking through the scenarios from the perspective of the science actors may help to avoid politicising science. Science diplomacy is a term that can give scientists, a feeling that they are part of some kind of 'lip service model' where talk about their role is not supported and taken seriously by other policymakers; as one participant clarified, protecting their integrity is important to scientists who are 'rightly careful about not being manipulated' or instrumentalised for vested national interests. One of the points raised in the discussion is that scientists are increasingly asked "who do you work for?" which implies that they represent a government or institution; instead, it was argued that the primary question should be "what do you work for?", which allows them to orient themselves towards global challenges and contribute to broader societal goals. The label itself may in certain instances do a disservice to the noble ambitions emphasised in some scenarios. What is clear is that the term is understood differently by academics and practitioners who nevertheless find themselves in a science diplomacy interaction space that requires them to understand each other.

When discussing the scenarios, the aim was to explore how the negative scenarios could be avoided and aspects of the scenarios that were regarded more desirably could be attained. One of the first conclusions was based on the observation that "where are we now" differs depending on what part of the world we consider. Different national and regional opinions, positions, and perspectives mean that elements of each of the scenarios are already a reality somewhere in the world today. Geography, for example, can be a critical factor – as conflict and contraction can be seen between the US and China – as can the policy sector – water issues create a very different context from inner and outer space. As a result, hybrid scenarios and nuances need always to be considered.

Another observation was that the focus on countries as the most important factor should be challenged. The participants raised the point that a nation state-centred approach is not necessarily the best way to accomplish planetary management. The scenarios, which are grounded in the model of national, cross-border and global interests (Gluckman et al., 2017), brought out critical comments regarding the organisational principles and pleas to think outside of the notion of the nation and "inter-national" cooperation. Social movements and scientific communities should be considered; other non-state actors need also to be involved. Issues (and external events including catastrophes) have the potential to bring together different stakeholders, including citizens, who show the ability to self-organize. This 'non-state' turn would make science diplomacy less concerned with linking to political process and politicisation but would rather emphasise civic science and scientific transnationalism or trans-governmentalism, the concept of which arose in the discussion.

In this context, academic freedom, scientific integrity, and ethics are key as ways of avoiding scientific instrumentalisation for national interests. On the other hand, the panellists reflected on the fact that scientists are members of organisations that are often paid by a country's taxpayers and that they can be influenced by national and commercial interests. Finally, it was discussed that sometimes scientists can inadvertently find themselves in a space of science diplomacy, and even when the context is not explicit and actors may not self-identify as diplomatic, they nevertheless act diplomatically, and their actions can have diplomatic consequences.

Application to the COVID-19 crisis and beyond the event

When we created the scenarios, a global pandemic and socio-economic crisis was not on our horizon; however, observing the discussions following the start of COVID-19 (science advise being transferred but also at times ignored, closing of borders, exchange of gene sequences and research results, vaccine nationalism, the push for open science, and exchange of pre-prints) shows us that the different scenarios were all in play at different phases and with different aspects and actors during the crisis. In the March 2021 final conference of the S4D4C project, there was a call for a global treaty on pandemics; success in that endeavour would be aided by understanding the scenario under which it would be developed. A policy brief developed in the project (Young, 2020c) has identified several key recommendations suggesting ways to move towards the more globally inclusive and cooperative models. These recommendations as well as the scenarios can provide ideas for future science diplomacy by inspiring starting points for discussions among stakeholders. They could be employed in the 'interactive spaces' that are called for in a governance framework for addressing global challenges (Aukes et al., 2021) as a way for participants to better understand the viewpoint of others. In short, the scenarios provide a framework for thinking through issues that have arisen in the COVID-19 crisis, and conversely, they can be used to think through the ways that responses to COVID-push the world towards each of these scenarios.

In general, future scenarios provide foresight for road-mapping processes. In our discussions of them, we find ideas for a roadmap of future research agendas that are both practical and academic. The concept of science diplomacy remains fuzzy and needs theoretical development to get past its current boundaries set out in the Royal Society's three-fold typology to better explain how science and diplomacy interact and co-develop each other. While the addition of a serious strain of thought related to interests is an important development, it should not be treated as an evolution of the concept, but rather as an additional layer of sophistication, which as we saw in the focus group raises as many questions as it answers. More such layers of sophistication are needed. In our report on the matters of science diplomacy (Young et al., 2020a) we have suggested nine others, but these do not foreclose on adding others. Specifically, more work both practically and academically on many of the themes that arose in the focus group are needed: specifying the role of global goods as a core element in global affairs, understanding the effects and impacts of global science and innovation divides and how to overcome them, and refining the role of scientists as independent and integrity-driven players in global policymaking. With the world teetering between geopolitical interest domination (not just between the USA and China but now also part of the EU's global discourse), and an increasingly critical need to address global challenges, science diplomacy's role is more important than ever. We share these scenarios in the hope that they can prove helpful to others in the pursuit of stronger and more effective science diplomacy.

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The World Academy of Sciences (TWAS)

Sneha Sinha*


Sneha Sinha

Foundation of TWAS

At the meeting of the UN General Assembly in 1953, President of the United States Eisenhower gave the famous 'Atoms for Peace' speech. He proposed the creation of the International Atomic Energy Agency (IAEA) under the aegis of the UN to ensure non-military and promote peaceful use of nuclear energy for lessening international tensions and peace.[1] A group of 12-nations (1956) negotiated and elaborated on the statute for the proposed IAEA, which came into force in 1957. IAEA aimed to promote research, development and practical applications of nuclear energy for peaceful purposes, and foster exchange of scientific and technical information 'with due consideration for the needs of the under-developed areas of the world'.[2]

The proposal for the creation of the International Centre for Theoretical Physics (ICTP) by Abdus Salam during its fourth General Conference in 1960 can be viewed as first significant step towards IAEA's efforts for promotion of East-West cooperation. A panel consisting of eminent theoretical physicists, representatives of international organisations was convened to discuss possibilities for its foundation. ICTP started to operate in Trieste on 5 October 1964, jointly supported by the Italian government, IAEA and UNESCO.[3] It acquired a worldwide reputation and continues to provide research training opportunities to physicists from developing countries, and has worked extensively towards reducing

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brain drain from developing countries.[4] It provides them opportunity to interact with the scientists from institutions across the world. Indian scientist, MGK Menon recognised role of science in society and in building bridges between countries.[5]

The origins of another milestone in this direction can be traced to the meeting of the Pontifical Academy of Sciences in 1981. During this meeting, Abdus Salam and MGK Menon noted that only scientists with high calibre could become members of international academies of science. They discussed limitations faced by the scientific community in developing countries and the lack of institutions that confirmed their academic credentials, advocated science, established standards of excellence and promote social, cultural, and economic development. Therefore, in a meeting with nine scientists (mostly from developing countries), Salam proposed the creation of an academy of sciences for developing countries. It sought to help the scientists from the developing countries of Asia and South America, by electing eminent scientists from developing countries and helping them nurture a community of scientists and promote research and exchange programmes to advocate science.[6] This led to the foundation of the Third World Academy of Sciences (later renamed as The World Academy of Sciences) in 1983.[7]

TWAS is hosted at the ICTP headquarters in Trieste, Italy. Its 42 founding fellows included scientists both from developed and developing countries. Nine of them were Nobel Laureates.[8] It aims to recognise excellence in scientific research, provide research facilities, promote scientific research by mitigating the challenges faced in the South; facilitate contacts between individual scientists and institutions in the South; and encourage North-South cooperation between institutions and centres.[9] Today, TWAS has a network of 1200 member scientists across various fields and subfields of science, including social and economic sciences.[10] In order to encourage young scientists, it also elects young affiliates from various scientific disciplines.

Building South-South and North-South collaboration

TWAS provides a rare forum for bringing together and shaping a scientific community for scientists and researchers belonging to varied disciplines of science from developing countries. At the same time, TWAS recognises and rewards scientific achievements of scientists in the South through prizes in various fields, including the TWAS-Lenovo Science Prize and young scientists' awards, etc.[11,12] Taking note of the limitations faced by scientists in developing countries, TWAS provides research grants, fellowships, training and access to advanced research facilities. It institutes various research fellowships like postdoctoral and PhD fellowship, Grants for Scientific Meetings for organising international, regional scientific meetings, workshops, symposia, conferences, etc. Research and Training in Italian Laboratories and TWAS Research Grants for specialised equipment and consumable supplies. TWAS has initiated various opportunities for visiting scientists for sharing expertise in developing countries. The visiting Scientists programmes also allow developing nations to invite professors and researchers to build expertise in the given field.[13] TWAS partners with institutions in developing countries like India, and invites for proposals from scientists and technologists as well as young scientists in basic sciences and other fields.[14] Contributing to ongoing COVID-19 outbreak, TWAS recently has called proposals on COVID-19 from Islamic Development Bank member countries.[15] There are also fellowships for women to support research related to SDGs.[16] Through these, TWAS has undertaken various capacity-building programmes to strengthen science in the developing countries of the global South.

Apart from encouraging and providing facilities for research to the researchers from the developing countries through its grants, awards and fellowships, the Academy has also developed institutional linkages and networks across the world, both in developed and developing countries. Thus, facilitating cooperation between scientific institutions in the Global South as well as North-South collaboration. It has established a global network with partners across the world including 43 institutions in Global North, 9 in Latin America and the Caribbean, 13 in Africa and Arab region and 21 in Asia-Pacific.[17]

TWAS has played an instrumental role in the creation of institutions dedicated to serving the scientific needs of developing nations. Recognising the role of women in advancing science, the Organization for Women in Science for the Developing World (OWSD), formerly known as the Third World Organisation for Women in Science (TWOWS) was established in 1989 and was jointly sponsored by TWAS and Canadian International Development Agency (CIDA). Currently, it has more than 6000 members across 147 countries (with greater participation from developing countries).[18] Another international organisations on the ICTP campus is the Inter Academy Partnership which also plays a significant role in capacity building, forming networks, focusing on science-based advice on national, regional, and global issues including sustainable development. TWAS, IAP and International Science Council (ISC) have initiated a project for coordinated response to support refugee scientists and displaced researchers.[19] It's Science in Exile Initiative is also a step in this direction. TWAS facilitated the establishment of the Third World Network of Scientific Organisations (TWNSO) in 1988 to promote science-based South-South and South-North partnership for sustainable economic development in the South. TWAS and TWNSO have various programmes including South-South collaboration for scientists in developing countries.[20] In 2013, TWAS together with the Chinese Academy of Sciences organised six centres of excellence to provide scientists from developing countries an opportunity to undertake advanced research at these centres.[21]

Science diplomacy and TWAS

TWAS recognises the importance of science-based policy advice and has been taking initiatives to facilitate the application of science in solving societal issues. Global scientific issues require global response and stronger partnerships. North-South linkages towards a global outlook of science to tackle issues and challenges that we face today. It collaborates with international organisations for solving global challenges including Global Research Council, Big Data, Solar Radiation Management Global Initiative, etc. In this direction, TWAS hosted the UN Conference in 2016, which brought together scientists of the UN Secretary-General's Scientific Advisory Board to provide inputs to the UN Secretary-General, Ban Ki-Moon on science in achieving SDGs. TWAS was one of the seven partners of the CATALYST Project which aimed to collect and disseminate best practices and knowledge in Climate Change and Disaster Risk Reduction.[22]

TWAS also attaches great importance to science diplomacy and is increasingly engaging itself in furthering science diplomacy through its training programmes, lectures, regional workshops, etc. It's capacity-building programmes include ASSAF-TWAS-AAAS regional training workshop in science diplomacy in South Africa (2018), BA-TWAS-AAAS regional workshop in Egypt (2019), TWAS-IAP workshop science policy and diplomacy for scientists in Italy (2019), TWAS-AAAS training programme for trainers in Italy (2019), S4D4C Workshop, AAAS-TWAS Course (2020) and TWAS-ASM regional workshop (2021), etc. AAAS and TWAS will be organising a course on science diplomacy this year in the virtual mode.[23] In 2019, TWAS joined the Big Research Infrastructures for Diplomacy and Global Engagement through Science (BRIDGES) network which deals with international research organisations, science diplomacy and international relations. TWAS organises science diplomacy lectures by experts and practitioners. Regional examples of science diplomacy and its role in solving issues and challenges facing them have been given some attention in the case of Africa and other areas after the outbreak of Ebola, sustainable water management, climate change, sustainable fisheries, energy. The opportunities for science diplomacy in tackling national, regional, and global issues have been flagged by TWAS through its lectures, training programmes, roundtables, workshops, etc.[24]

For wider outreach and furthering research, TWAS publishes its annual reports which give a snapshot of its training programmes, opportunities provided to researchers from the developing world and networking activities. The Academy also publishes *TWAS Newsletters* quarterly focusing on various issues and challenges faced by the developing countries. The bi-monthly *TWAS Plus* provides a look into the initiatives including fellowship, grants, prizes, awards, etc. undertaken by the Academy to support scientists from developing countries. TWAS also publishes a series of book 'Excellence in Science' to explore the historical development of science centres, challenges faced and their role in the nation's sustainable economic development. The first volume was published in 2007 which focused on the Central Drug Research Institute in Lucknow, India. Since then, 11 volumes have been published on various institutions in Colombia, Pakistan, Tanzania, Botswana, Uganda, China, Madagascar, Tunisia. Costa Rica, etc. The latest issue delves into the International Centre for Integrated Mountain Development, an intergovernmental science centre involving eight nations. The Research Reports cover issues concerning both North and the South like safe drinking water, sustainable energy, and capacity building. TWAS also publishes on contemporary issues like the COVID-19. In a statement, last year, it called for an inclusive and global approach to tackle the ongoing pandemic.[25] TWAS research brings forth the issues of the developing world as well as its scientific achievements to link science with their socio-economic issues and strengthen North-South cooperation.

Conclusion

Since its inception, TWAS served as one of the 'most articulate and forceful voices for the promotion of excellence in scientific research and the advancement of science-based development in the developing world. Beyond being an honorary society for recognizing prominent scientists of developing countries, TWAS has made efforts to link scientific research to issues related to problems faced by developing countries as well as sustainable economic development'.[26] TWAS recognises the role of science diplomacy in building bridges and solving various regional and global issues, therefore has been contributing towards capacity building in Science Diplomacy and building networks with institutions. Greater participation and closer collaboration in science diplomacy and related fields between institutions in the Global South and TWAS will be significant in evolving a Southern Perspective of science diplomacy, which at present remains largely restricted mostly to the North. This will draw attention on issues that are specific to the South and help in finding relevant solutions. Enhanced engagement of scientists, science academies and S&T institutions, with TWAS will be significant for showcasing the issues faced by developing countries to the Global North as well as facilitating greater North-South cooperation. TWAS represents collective voice of scientists from the South and has global aspirations. As science academies and funding agencies are grappling with various issues that are at the interface of science and society, it is obvious that TWAS will also be addressing them. From a science diplomacy and science policy perspective, it's work and role will be all the more important in the years to come, given the multiple challenges before humankind and the critical role of science and technology in finding sustainable and equitable solutions in tackling them and the dire need for better harnessing of Science, Technology and Innovation in the global South.

Endnotes

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8. The details of TWAS founding fellows can be retrieved from https://twas.org/directory/founding-fellows.
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[15] More information can be accessed at https://twas.org/opportunity/isdb-twas-joint-research-technology-transfer-grant-2021-quick-response-research-covid-19.

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NOTE ON INSTITUTION

Aryabhatta Research Institute of Observational Sciences (ARIES): Open to International Cooperation

Debanjana Dey*

Debanjana Dey

Aryabhatta Research Institute of Observational-Sciences (ARIES) specialises in observational Astronomy and Astrophysics and Atmospheric Sciences. It is one of the premier institutions in India which provides national optical observing facilities for research along with in-house research capacity which conducts research in solar astronomy, stellar astronomy, star clusters, stellar variability and pulsation, photometric studies of nearby galaxies, quasars, transient events, understanding the complex physical and chemical processes governing Earth's atmosphere etc.

The institute was established as a 'State Observatory' at Varanasi in 1954, later shifted to Manora Peak, Nainital, Uttarakhand in 1956 and hosts the largest telescope of aperture 104 cm in India since 1972.[1] The telescope provides an observation facility and has contributed to several photometric, spectrophotometric and polarimetric studies. Located at an opportune geographic position, almost in the middle of 180° wide longitude band, between Canary Island (20° West) and Eastern Australia (157° East) and at an altitude of 1951 metres, ARIES has benefited and made unique contributions to astronomical research, particularly those involving time-critical phenomena. One such was the first successful attempt to observe the optical afterglow of gamma-ray bursts.

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Scientific research and equipments at ARIES

In 2016, ARIES set up India's largest 3.6-metre Devasthal Optical Telescope (DOT) at Devasthal (79.7 E, latitude of 29.4 N, altitude of approximately 2450 metres above mean sea-level), a site selected for its dark and transparent skies, low perceptible water vapour content, minimal fluctuations in the ambient temperature during the night, and distance from city lights.[2] The 3.6 metre DOT is the largest fully steerable optical telescope in Asia. It is equipped with instruments providing spectral as well as imaging capabilities at optical and near-infrared wavelengths. Scientists at ARIES have built an indigenously developed optical spectrograph on the 3.6 metre DOT that can achieve various science goals such as locating sources of faint light from distant quasars and galaxies in a very young universe, regions around supermassive black-holes around the galaxies, and cosmic explosions.[3] In addition to optical studies of a wide variety of astronomical topics, it can be used for optical follow-up observations of cosmic sources identified in the radio, ultraviolet, x-ray and gamma-ray wavelengths.[4] The proposals from national and international researchers for observing through the telescope are accepted in two cycles through the DOT Online Proposal Submission System (DOPSES).[5] The successful proposers are granted observation rights and exclusive access to their scientific data for the duration of a proprietary period, which expires one year after the date of observation.[6] Beyond that, all data are made public globally which enable the wider international astronomical community to access the data for research. At present, most of the Project Investigators are either from Indian Institutions or from Belgium. There are no usage charges levied for the telescope time but based on prior commitments, of the total observing time on 3.6 metre DOT, 33 per cent guaranteed time is reserved for astronomers from ARIES and 7 per cent guaranteed time is for astronomers from Belgium instead of their financial contribution of 7 per cent of telescope construction cost.

Also, installed in Devasthal is a 1.3-metre diameter Devasthal Fast Optical Telescope (DFOT). The focal length to diameter ratio (focal-ratio) of the overall telescope optics is four, making it a very fast system with a total field view of the sky up to 66 arc minutes in diameter. DFOT has been installed by DFM Engineering Inc., the USA in 2010 and is run by ARIES since then. The darkness and sub-arcsec observation at the Devasthal site make DFOT a superior facility for carrying out valuable astronomical research in the field of faint objects. Though this telescope is dedicated to the core scientific programs carried out at ARIES like monitoring of transients' events (like gamma-ray bursts, supernovae explosions, transiting exoplanets), variability of stars in the Milky way, wide-field imaging of star clusters, variability in stars, stars clusters, etc, it is also being used for diverse scientific topics by various researchers through joint projects with the ARIES researchers. Scientists from Belgium, Thailand, Taiwan, etc. have been using this facility for various scientific programs and foreign scientists and researchers are welcome to use this facility and collaborate with ARIES scientists.

Along with the astronomical infrastructures, the Atmospheric science division of ARIES (established in 2002) has also set up a facility for wind profiling using stratosphere-troposphere radar (ST Radar) in Monera peak along with lidar, balloon-borne measurements of trace gases etc. The ST Radar is an active aperture phased array designed for operating at a frequency of 206.5 MHz, used as an experimental tool to measure various atmospheric parameters used for basic atmospheric research, weather forecasting and disaster management. Such high-altitude radar in the VHF band (~200 MHz) along with antenna arrays over the rooftop has been built for the first time in India. The ST Radar is operated in the common-mode observation at 06 GMT and 12 GMT and the data is available to all researchers. However, researchers from national and international institutes can access the radar facility through joint projects with the ARIES researchers and for specific observation, interested researchers can send research proposals to ARIES. For both ST Radar and 1.3 m DFOT, no guaranteed time is reserved for the international scientific community but observing time is allocated to international collaborators without any usage charge.[7]

Facilities for National and International participation

All the three major facilities at ARIES – DOT, DFOT and ST Radar have well developed infrastructure and connectivity between the locations enabling excellent observational facilities. All these three major facilities at ARIES have well-developed infrastructure and connectivity between the locations enabling excellent observational facilities. The geographic location of the observatory at Devasthal has global importance for time-critical observations and time-domain astronomy, a feature that makes this facility exclusive for astronomical research. Also, the ST Radar provides a unique opportunity to study 3D wind structure, monsoon troughs, turbulence parameters, gravity waves in the troposphere, jet streams, troposphere-stratosphere exchange processes, climatology of the horizontal wind field and wind shear etc. At present, the ARIES has signed Memorandum of Understandings with various institutes and universities for accessing the facilities and observation time are provided on mutual basis to facilitate collaborative scientific programs. Further, all these three facilities have been opened up for national and international participation.

Endnotes

1 Sinvhal, S.D. 2006. "The Uttar Pradesh State Observatory – some recollections and somehistory (1954 – 1982)". *Bulletin of the Astronomical Society* of *India. 34. pp.65-81.*

2 Sagar, R. Kumar, B. and Omar, A. 2019. "The 3.6 metre Devasthal Optical Telescope: from inception to realization". *Current Science*. 117(3). pp. 365-381.

3 DST (2021). "Made in India spectrograph, commissioned on Devasthal Optical Telescope, can locate faint light from distant celestial objects". *Department of Science & Technology*. Retrieved from https://dst.gov.in/made-india-spectrograph-commissioned-devasthal-optical-telescope-can-locate-faint-light-distant on 26th March, 2021.

4 Details on capabilities of DOT and its instruments can be accessed at https://www.aries.res.in/.

5 The Call for proposals is announced twice a year on 1st July and 1st November and proposals can be submitted at http://dopses.aries.res.in.

6 Policies and procedures for carrying out with 3.6m DOT can be found at Science observing policy document.

7 Once observing time is allocated, on site accommodation is provided to visiting observers with minimal fee. Canteen is also available to cater food to the visiting observers.

WEBINAR REPORT

Promoting India-Taiwan Cooperation in Science, Technology & Innovation (STI): Way Forward

Introduction

Bilateral engagement between India and Taiwan has improved significantly over the years in the realm of trade, investment, tourism, culture, and education. Scientific exchanges, people-to-people interactions etc. between the two countries have also increased along with growing trade and investments. The India-Taiwan Joint Committee on Cooperation in Science and Technology holds regular meetings, to foster science, technology and innovation (STI) cooperation between the two countries. The India-Taiwan S&T cooperation programme extends financial support through a joint call for proposals to researchers in India to carry out research and scientific experimentation with their Taiwanese counterparts. The programme has recently in February 2021 invited research proposals in several priority areas like renewable energy, clean energy, IoT, big data, cybersecurity, micro/nano-electronics, embedded systems & sensors, biotechnology, healthcare, including, functional genomics, drug development and biomedical devices, etc.[1]

The scope of cooperation between Taiwan, a fast-growing industrialised economy with a deep footprint in global supply chains for medium and high-tech goods and an emerging economy like India is immense and will be mutually beneficial. Presently, there are about 100 Taiwanese companies in sectors such as steel, engineering, electronics, machinery, construction, and financial services, and most importantly in the ICT sector in India. Taiwan through its New Southbound Policy aims to diversify its trade and investment partners and boost STI engagement between Indian and Taiwanese academic and research institutions. The two countries held a virtual exhibition on Taiwan-India exchanges under the New Southbound Policy in

December 2020. STI cooperation between India-Taiwan can aid innovation and the manufacturing sector through capacity building/skill development and creating employment opportunities.

To foster STI collaboration between the two countries, RIS and the Prospect Foundation, Taipei organized a webinar on the theme, 'Promoting India-Taiwan Cooperation in Science, Technology and Innovation (STI): Way Forward' on 25th February 2021. The opening remarks by *Prof. Sachin Chaturvedi, Director General, RIS and Dr. I-Chung Lai, President, Prospect Foundation* stressed the need for greater collaboration between India and Taiwan in S&T, especially focusing on electronics and high technology areas. Various areas of S&T collaboration were identified by Prof. Chaturvedi including big data, clean energy, embedded system, functional genomics, biomedical, etc. The partnership between RIS and Prospect Foundation may help in developing policy roadmaps to facilitate collaboration. Sectors like IT, AI, automatic engineering was highlighted by Dr. Lai where India and Taiwan could collaborate in facilitating S&T intervention for mutual benefit. The webinar included four sessions namely, Science, Technology and Global Economic Order; ICT and Semiconductor Industry; Smart Manufacturing and Industry 4.0 and Science Parks in India and Taiwan-Experiences and Scope for Mutual Learning.

Science, technology and global economic order

In the session, Science, Technology and Global Economic Order, *Amb. Bhaskar Balakrishnan, Science Diplomacy Fellow, RIS* outlined greater opportunities/prospects for S&T cooperation between India-Taiwan, and the need for S&T collaboration in tackling global challenges like the COVID and climate change, which require coordinated efforts of several countries. India has taken proactive measures to lower the carbon intensity of GDP and make a gradual transition towards a greener mode of energy. The participation in global mega-science projects like CERN large Hadron collider, ITER fusion energy research etc. have provided access to cutting-edge S&T. India has invested substantial resources and efforts in projects like International Solar Alliance (ISA) and has been at the forefront in building collaboration in renewable energy and biotechnology. He emphasised that there is a need for greater collaboration of the kind used for ITER and CERN for S&T to enhance climate science and global climate modelling to predict climate change and time, intensity, and location of extreme climate events. International cooperation in S&T between countries can foster S&T development which can permeate into all sections of the society and mitigate global challenges.

Recognising the ongoing paradigm shift in the global economic order with a focus on economic and national security, *Dr. Roy Lee, Senior Deputy Director, Taiwan WTO & RTA Center, Chung-Hua Institution for Economic Research (CIER)*stressed the need for global supply chain reform. Critical sectors, infrastructures and processes for economic security depend on government intervention, and vulnerability could arise from the supplier and natural resource dependence, espionage, and leakage of sensitive information, etc. The recent executive order of the US President on

American Global Supply Chain seeks to review the vulnerabilities and risks faced in semiconductors, high efficient batteries, pharmaceuticals, defence and energy sectors. It may trigger a change towards minimising dependence on supplies from China. Similarly, the EU is also reviewing its policy about the global supply chain, which opens opportunities for the development of new generation supply chains. India-Taiwan STI cooperation should facilitate supply chain relocation to support next-generation technologies (5G to 6G, green technologies, computing capacity for AI, etc.), and ensure security and trust in technologies and data sharing.

ICT and semiconductor industry

During the second session on ICT and Semiconductor Industry, *Professor V. Kamakoti, IIT-Madras* highlighted the growing market and steady increase in demand in India for the 180-nanometre semiconductor technology which could provide opportunities and offer a suitable environment for Taiwan to increase its investments. Indian designs and IP namely, 5Gi and SHAKTI can boost collaboration between the two countries. Telecommunications Standards Development Society's 5G Radio Interface Technology named as 5Gi has cleared the rigorous processes of the International Telecommunication Union (ITU) and conforms with the International Mobile Telecommunications -2020 vision and stringent performance requirements. SHAKTI is an open-source processor development initiative. The scope of collaboration between Indian-Taiwanese industries, academic institutions and individuals in these technologies is immense.

A holistic view of the Taiwanese companies in India and the Indian industrial sector is important for assessing why some areas/sectors were growing faster than others, according to *Mr. Stanley Wang, Deputy Director-General, International Division, Institute for Information Industry.* There is a need for a robust supply chain to boost sectoral development. The success of Taiwanese companies rests on their ability to understand the needs of the consumers and the market which dictates the development and relocation of their supply chains. Recently Taiwan has relocated its supply chain to Japan, UK, and Europe but not to India. Therefore, India must provide an enabling ecosystem to foster market dynamics and supply chain needs to facilitate Taiwanese companies to set up their units in India. India's strength in IC design can initiate collaborative endeavors between the two countries and offer India immense potential to develop and strengthen its ICT industries. A strong base of ICT industries is often followed by a boost in manufacturing automatically. Taiwan's success in the ICT and semiconductor industry has been based on both technology push and market pull. A similar combination of pull and push can lead India to be a big player in ICT and increase its footprint in the global supply chain. Investments and infrastructural support by the Government of India for the development of ICT industries will be critical.

Smart manufacturing and industry 4.0

During the third session on Smart Manufacturing and Industry 4.0, *Mr. Kalyan Ram, CEO, Electronic Solutions Pvt. Ltd & Dy. Director, Automation Industry Association,* focused on the need for a technology-driven manufacturing ecosystem with reduced waste and optimum utilisation of resources in India. Recent developments include a joint initiative by IIT Delhi and **Automation Industry Association (AIA)** to set up a fully integrated Smart Manufacturing and Learning Facility, and Common Engineering Facility Centre (CEFC) to promote innovation and adopt Industry 4.0 solutions. India's collaboration with Taiwan can strengthen the enablers for Industry 4.0 like big data analytics, cybersecurity, simulation, autonomous robots, industrial internet of things etc. Taiwan is ahead of India in global machine tool production, while India was the sixth largest consumer of machine tools in the world. The collaboration between the two countries will cater to the demand and supply. Setting up manufacturing facilities by Taiwanese companies in India will open a market and boost smart manufacturing processes, which would be mutually beneficial.

Dr.Yau-Jr Liu, Vice President, Taipei University of Marine Technology mentioned that there has been reports on several industries relocating their production site from China to India during the post-pandemic era. Taiwan occupies 4th position in terms of global export of machine tools and has excelled in smart manufacturing in aviation, medical devices, electronics and semiconductors. Its progress in the smart manufacturing and machine tools industry rests on skill development and capacity building through vibrant training programmes and industry-academia collaboration. Taiwan has also initiated measures to strengthen ties between overseas Taiwanese firms and local immigrants for furthering overseas development of Taiwanese industries or fostering collaboration with them. Training programmes and sharing best practices were central to the success of smart manufacturing industries in Taiwan. India and Taiwan should focus on academic collaboration between the two countries and involve Indian universities and IITs to work with Taiwanese institutions towards the development of smart manufacturing.

Science parks in India and Taiwan- experiences and scope for mutual learning

In her presentation, *Dr.Deepanwita Chattopadhyay, Chairman and CEO, IKP Knowledge Park,* described Indian Science parks with a focus on IKP, Hyderabad and its evolving roadmap. Indian science parks have evolved as research and innovation hubs, while Taiwanese Science parks have focused on industrial and manufacturing activities for development. India being the 6th largest economy with a nominal GDP of US$ 2.61 trillion is the 3rd largest start-up economy and ranked 48th in the Global Innovation Index ranking. India has 6,149 industrial parks and 60 software technology parks India, with about 95,000 start-ups and small businesses incorporations. Three Indian cities namely, Bengaluru, New Delhi, and Mumbai figure in the top 100 global innovative clusters, while the Hyderabad cluster is yet to figure in the list. The Hyderabad cluster - IKP has been instrumental in creating an innovation and knowledge hub locally as well as extending them to other parts of the country. This has been possible by nurturing start-ups to enhance their innovative potential and subsequently develop a sustainable innovation cluster. IKP was the first Life Science Research Park in India. It became a hub for pharma companies and a base to produce APIs, agri-seed companies, vaccine companies etc. The presence of genome valley, academic and R&D institutions in and around IKP provides the ecosystem to build a knowledge economy through research and innovation clusters. IKP brings together Indian and global partners to nurture and fund over 700 innovation projects and early startups, and its development goals and strategies have evolved over the years. It has evolved from fostering an ecosystem for start-up incubation in 2005; to enabling faster scale up, rapid prototyping and maker space and innovation culture in 2014; and to transit from program implementer to orchestrator for advancements in deepening and co-creation of solutions in health and plant systems in 2021.

Ms. Vivian Huang, Director General, International Division, Institute for Information Industry emphasized the scope for experience sharing between India and Taiwan on IT parks. She presented a brief overview of Indian industries focusing on the market share of smartphones where China's mobile phone brands have 75% of the Indian market share in 2020, an increase of 4% in comparison to 2019, thereby setting a record. She also mentioned the status of Taiwanese IT companies in India located in the Bengaluru – Chennai Industrial Corridor and Taiwan sees value for their science parks and IT parks in this corridor. Two case studies include the Technology Innovation International Park (TIIP) of Century Development Corporation in Bangalore and Taiwan Major IT Related Park. Century Development Corporation (CDC), a Taiwanese company has developed the Taiwan industrial cluster - Technology Innovation International Park (TTIP) in Bengaluru. TIIP is in its first phase of construction and CDC has made several investments to develop infrastructure, including electronic waste processing centre and common amenities. The industrial park will be developed as an integrated industrial township for Taiwanese high-tech industries, targeting electronics, smart machinery, electric vehicle and biotechnology industries. In October 2019, the Japanese company Mitsui & Co announced the setup of a joint venture with Taiwanese motor manufacturer TECO Electric & Machinery Co Ltd. to create a manufacturing facility for electric vehicle (EV) motors with a capacity of 110000 sets per year. Ms. Huang also presented a map to indicate major industrial parks in Taiwan like Science Park, Software Park, Biotech Park, Startup Innovation Park and Agriculture Tech Park.

Way forward

The closing remarks for the webinar were delivered by Dr. Lai and Dr. Balakrishnan and and it was suggested to pursue collaboration between RIS and Prospect Foundation for joint policy reports and studies, the formation of working groups from academicians, industry personnel from both sides for collaboration, research, studies, and mutual stakeholder engagement on the themes like ICT and Semiconductor Industry, Smart Manufacturing and Industry 4.0 and Science Parks.

Endnotes

1 See, the Joint Call for Proposal 2021 (INDIA-TAIWAN Programme of Cooperation in Science and Technology). Retrieved from https://www.most.gov.tw/india/en/detail/e119af15-e301-4716-b0c2-412ce373f658.

Science Diplomacy Events

Global Young Academy (GYA) Workshop on Science Diplomacy in South Asia

The Global Young Academy's South Asia working group represents a unique initiative that seeks to forge new scientific collaborations by bringing together scientific and policy experts from three countries in the region, namely Bangladesh, India, and Pakistan. The South Asian region faces many common challenges, and the GYA provides a common platform for discussions on these problems and to promote a common understanding of these problems and attract the attention of scientific communities in these countries to such problems. Science diplomacy is an important tool in these efforts and the GYA Working Group mainly looks at scientific diplomacy between the three nations from South Asia, namely which share a long history of cultural ties and familial ties. To promote science diplomacy related awareness and initiatives in South Asia, the GYA held a five-day online workshop on Science Diplomacy in South Asia in November and December 2020.

The GYA workshop included a total of 100 participants from seven countries in the region (India, Bangladesh, Pakistan, Nepal, Sri Lanka, Maldives, and Bhutan). The participation of a large number (about 61 per cent) of female participants in the workshop was seen as an encouraging sign for promoting the role of women in the STEM and science diplomacy field. The workshop mainly aimed to raise awareness on Science Diplomacy among the South Asian populace, impart conceptual and practical knowledge, and allow participants to share their ideas and views in a structured manner. The first session of the workshop was held on 21st November 2020 and the opening remarks were delivered by the GYA Co-Chair Dr Anindita Bhadra (India), and by chairpersons from National Young Academies in the region. Dr Bhaskar Balakrishnan, former Indian Ambassador and Science Diplomacy Fellow at RIS New Delhi delivered the lectures on "History of Science Diplomacy". Other distinguished speakers included Mr. Rômulo Neves, a practicing diplomat from Brazil, who spoke on "Art of Science Diplomacy" and a special lecture by Professor Pierre Bruno Ruffini, a renowned French academic on Science Diplomacy.

The second session held on 28th November 2020 included a lecture by three eminent global experts. The first lecture was delivered by Dr Marga Gual Soler on the topic 'Science Diplomacy in Action: Strategies, Tools & Skills'. The lecture was followed by a detailed discussion with participants. The second lecture delivered by Dr Jauad El Kharraz on 'Lesson from Middle Eastern water diplomacy for South Asia'. The third lecture was delivered by Dr. Chagun Basha on the 'Role of Multilateral Organisations in Science Diplomacy'. The last lecture was delivered by GYA member and working group co-lead Dr Monir Uddin Ahmed (Saudi Arabia) on the topic "Present scenario of scientific collaboration in South Asia".

The third session held on 5 December 2020 started with the lecture by Brazilian Diplomat Mr Pedro lvo Ferraz da Silva on the 'Scope and importance of science and Innovation Diplomacy for developing economies"' Dr Gihan Kamel's lecture focussed on the theme 'Regional peace and science diplomacy – middle-eastern experiences for South Asia'. Muhammad Adeel delivered the lecture on 'Careers for early career researchers in science Diplomacy and Science Policy'. This was followed by a breakout session in which participants were clustered into different small groups to discuss the UN SDGs, their importance and achievement through science diplomacy concerning the south Asian region.

The fourth session held on 12th December 2020 started with a talk by GYA member Mr. Suraj Bhattarai (Nepal) on the theme, 'Science Diplomacy for Scientific Achievements in South Asia'. This was followed by GYA alumnus, Mr. Aftab Ahmed's(Pakistan) talk on the theme, 'Need of science diplomacy in South Asia'. Another GYA alumnus, Mr Uttam Babu Shrestha (Australia) shared his thoughts on the topic, 'Reinventing Science diplomacy in South Asia' and then GYA member Mr. Meghnath Dhimal (Nepal) discussed the 'Recommendations for South Asia'. The last lecture of the workshop was delivered by GYA member Mr. Almas Taj Awan (Brazil) on 'Communication as a tool for Science Diplomacy'. Finally, the workshop participants delivered presentations in small groups on their chosen UN SDG and the role of science diplomacy to achieve the same in the region.

The closing ceremony of the workshop was held in the last session of the workshop on 13th December 2020. The closing ceremony of the workshop saw participation from guests from the Asian region. The GYA workshop provided an important platform for various GYA members, global experts, and participants to share their thoughts on science diplomacy in South Asia and made a good beginning on initiating conversation on these issues in the region. For more details, please see the GYA webpage on the science diplomacy workshop in South Asia.[1]

India International Science Festival (IISF-2020)

The sixth India International Science Festival was held from 22nd to 25th December 2020. The Council for Scientific Research (CSIR) spearheaded the annual event IISF 2020 with the support of the Department of Science and Technology (DST), Ministry of Earth Sciences (MoES), Department of Biotechnology (DBT), Indian Council of Medical Research (ICMR) and Vijnana Bharati (VIBHA). The event with the theme 'Science for Atmanirbhar Bharat and Global Welfare' was held in virtual mode. IISF celebrates the achievements of India's S&T advancements. On an opening day, the National Institute of Ocean Technology (NIOT), Chennai; ICMR, Gorakhpur; and Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune organised their curtain-raiser events. Dr Harsh Vardhan addressed the virtual curtain raiser program. Prime Minister, Narendra

Modi delivered the inaugural address at IISF 2020. An outreach programme to sensitize young minds was organised by Bharatiya Vidya Bhawan's Mehta Vidyalaya and Hubs School for the IISF 2020. Popular Science lectures were delivered, and the vision, history and importance of the India International Science Festival were discussed.

Numerous plenary sessions were arranged on different aspects of S&T. Some new themes included History of Indian Science, Philosophy and Science, Agri-tech, Clean Air, Energy, Waste & Sanitation, Biodiversity, Science Diplomacy etc. Its participants included students, industrialists, entrepreneurs, innovators, teachers, science communicators, technocrats and scientists. Science Diplomacy was introduced in the event to spread awareness and bring forth the importance of S&T in diplomacy among scientists and policymakers. The three sub-themes of the session included 'Science Diplomacy for Aatmanirbhar Bharat'; 'Setting Science Agenda for Diplomacy during India's Presidency of G20, BRICS & SCO'; and 'Science for Diplomacy and Diplomacy for Science'. Policymakers, diplomats, researchers, academics, and industrial leaders were among fifteen eminent panelists' in these sessions. They put forth their views on the role of science diplomacy in economic growth, industrial research & trades, diplomatic relations, mega-science projects and gender equality. The session saw wide participation, and apart from eminent speakers, Dr Harsh Vardhan; India's G20 Sherpa, Shri. Suresh Prabhu; and Prof. Ashutosh Sharma also addressed the gathering and underlined the importance of science diplomacy for fostering national goals and enrich India's image at the global level. The event also ran an Essay Writing Competition on the topic 'Necessity for Science Diplomacy'.

The IISF valedictory session was attended by the Vice President, M. Venkaiah Naidu, Dr. Harsh Vardhan, Dr. Shekhar C. Mande and other dignitaries. Various events were held on different aspects of S&T to highlight the role of Indian Science in elevating society and tackling the ongoing pandemic.

S4D4C Final Networking Meeting

S4D4C's final networking meeting 'Addressing Global Challenges Together: The Role of Science Diplomacy' was held during March 15-19, 2021. The week-long meeting was attended by nearly 765 attendees and brought together 120 speakers during 31 sessions dealing with various aspects of science diplomacy. The event saw diversity in the choice of speakers, belonged to 30 countries from across the world. Numerous plenaries, parallel and round tables were organised on varied themes of science diplomacy. The opening ceremony gave a snapshot of S4D4C's initiatives in furthering science diplomacy. The meeting captured views of various stakeholders including ministers, policy-makers, diplomats, scientists, representatives of international organisations, science diplomacy institutions, experts and researchers. Apart from Europeans, a representative from developing countries also discussed issues, challenges and steps taken in their country. The meeting reflected on the existing theoretical understanding of science diplomacy and issues concerning cooperation versus collaboration and its north-centric discourse. The role of scientists and issues facing science and policymaking, the need for an ecosystem with all stakeholders and adapting science advice mechanism were also underlined. Capacity building in science diplomacy and the lack of visibility of universities in science diplomacy were integral to the discussions.[2]

International STI cooperation will entail sharing lessons learnt, best practices and evolving governance mechanisms. Therefore, a roundtable brought together speakers from the United Kingdom, South Africa, Netherlands and Switzerland, who gave an account of the science diplomacy initiatives in their respective countries. Apart from involving multiple stakeholders, the meeting also stressed the role of multilateral and inter-governmental organisations in catalyzing science diplomacy for addressing societal challenges. The São Paulo Innovation and Science Diplomacy School (InnSciD SP) brought together speakers from Brazil, Nigeria and India. The networking meeting also included breakfast sessions with practitioners of science diplomacy. It allowed attendees to engage actively through Q&As, live chats and other networking options. One of the most striking outcomes was the launch of the EU Science Diplomacy Alliance launched with the three Horizon 2020 projects i.e. EL-CSID, InsSciDE and S4D4C at its core along with other institutions.

Endnotes

1 For details, see https://globalyoungacademy.net/gya-science-diplomacy-in-south-asia-webinar-series/.

2 A detailed article on the event 'Dear Science Diplomacy – Where do you want to go (From Here)?' is available at https://www.s4d4c.eu/guest-article-on-the-s4d4c-networking-meeting/.

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FISD Forum for Indian Science Diplomacy

CALL FOR PAPERS

SCIENCE DIPLOMACY REVIEW (SDR)
SEPTEMBER 2021 ISSUE
(Volume 3, No. 3)

Editors: Prof. Sachin Chaturvedi, Amb. Dr. Bhaskar Balakrishnan and Dr. Krishna Ravi Srinivas

Science Diplomacy Review (SDR) a multidisciplinary, peer-reviewed international journal, is a forum for scholarship on theoretical and practical dimensions in science diplomacy. It seeks to discuss and engage with the developments, issues, perspectives and institutions in science diplomacy. We invite contributions on issues related to science diplomacy in the form of research articles, perspectives, essays, book reviews and review articles. We welcome manuscripts on history of science diplomacy, historical case studies in science diplomacy. The role and relevance of science diplomacy in understanding and mitigating the present COVID-19 outbreak as well as epidemics in future, SDGs, and issues of global 'commons' and other global challenges in the post-COVID world are also welcome. We encourage contributions from scientists, diplomats, policymakers, researchers, research scholars and representatives of civil society for the forthcoming September 2021 SDR issue.

SDR is an open access journal published by Forum for Indian Science Diplomacy (FISD) based at Research and Information System for Developing Countries (RIS), New Delhi, India. RIS is an autonomous independent policy research think tank with the Ministry of External Affairs. The Science Diplomacy Programme funded by the Department of Science & Technology is being implemented by RIS.

Most challenges facing the world today including the present COVID-19 outbreak, climate change, environmental degradation are complex, interdependent and transnational. The Sustainable Development Goals (SDGs) which seek to address numerous global challenges also require a multilateral and internationally coordinated response. Science, Technology and Innovation (STI) lies at the core of these efforts. Finding relevant solutions to these challenges require leveraging STI through effective multilateral and global partnerships between scientists, policymakers and diplomats. Science diplomacy assumes a crucial role in achieving SDGs, and for development cooperation to address global concerns. It calls for international science cooperation, dialogues and engagements between various stakeholders and countries. Science diplomacy is increasingly adopted as a useful tool by many governmental and non-governmental organisations in both developed and developing countries.

SDR has been launched as a journal, inter alia, to reflect upon and debate on the above-mentioned themes.

Categories: Submit manuscripts including, full length articles and essays (4,000 – 6000 words), perspective (2,500 - 4,000 words) or book reviews/report reviews/ event reviews (1,000 - 1,500 words) by July 21, 2021 to **science.diplomacy@ris.org.in** with "SDR – September 2021 Issue" in the subject. We are open to considering longer articles as long as they are relevant to the overall objectives of SDR. Previous SDR Issues can be accessed on **http://www.fisd.in/science-diplomacy-review.**

G20: Call for Papers

G20 is gaining importance as a global platform for articulation of economic, social and development issues, opportunities, concerns and challenges that the world is confronting now. Over the years, G20 has witnessed a significant broadening of its agenda into several facets of development. India is going to assume G20 presidency in 2022 which would be important not only for the country but also for other developing countries for meeting the Sustainable Development Goals and achieving an inclusive society. India can leverage this opportunity to help identify G20 the suitable priority areas of development and contribute to its rise as an effective global platform.

In that spirit, Research and Information System for Developing Countries (RIS), a leading policy research institution based in New Delhi, has launched a publication called G20 Digest to generate informed debate and promote research and dissemination on G20 and related issues. This bi-monthly publication covers short articles of 3000 to 4000 words covering policy perspectives, reflections on past and current commitments and proposals on various topics and sectors of interest to G20 countries and its possible ramifications on world economy along with interviews of important personalities and news commentaries.

The Digest offers promising opportunities for academics, policy makers, diplomats and young scholars for greater outreach to the readers through different international networks that RIS and peer institutions in other G20 countries have developed over the years. The interested authors may find more information about the Digest and submission guidelines on the web link: **http://www.ris.org.in/journals-n-newsletters/G20-Digest.**

Guidelines for Authors

1. Submissions should contain institutional affiliation and contact details of author(s), including email address, contact number, etc. Manuscripts should be prepared in MS-Word version, using double spacing. The text of manuscripts, particularly full length articles and essays may range between 4,000- 4,500 words. Whereas, book reviews/event report shall range between 1,000-15,00 words.

2. In-text referencing should be embedded in the anthropological style, for example '(Hirschman 1961)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary only if the cited portion is a direct quote). Footnotes are required, as per the discussions in the paper/article.

3. Use's' in '-ise' '-isation' words; e.g., 'civilise', 'organisation'. Use British spellings rather than American spellings. Thus, 'labour' not 'labor'. Use figures (rather than word) for quantities and exact measurements including per centages (2 per cent, 3 km, 36 years old, etc.). In general descriptions, numbers below 10 should be spelt out in words. Use fuller forms for numbers and dates— for example 1980-88, pp. 200-202 and pp. 178-84. Specific dates should be cited in the form June 2, 2004. Decades and centuries may be spelt out, for example 'the eighties', 'the twentieth century', etc.

Referencing Style: References cited in the manuscript and prepared as per the Harvard style of referencing and to be appended at the end of the manuscript. They must be typed in double space, and should be arranged in alphabetical order by the surname of the first author. In case more than one work by the same author(s) is cited, then arrange them chronologically by year of publication.

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As part of its ongoing research studies on Science &Technology and Innovation (STI), RIS together with the National Institute of Advanced Studies (NIAS), Bengaluru is implementing a major project on Science Diplomacy, supported by the Department of Science and Technology. The programme was launched on 7 May 2018 at New Delhi. The Forum for Indian Science Diplomacy (FISD), under the RIS–NIAS Science Diplomacy Programme, envisages harnessing science diplomacy in areas of critical importance for national development and S&T cooperation.

The key objective of the FISD is to realise the potential of Science Diplomacy by various means, including Capacity building in science diplomacy, developing networks and Science diplomacy for strategic thinking. It aims to leverage the strengths and expertise of Indian Diaspora working in the field of S&T to help the nation meet its agenda in some select S&T sectors.

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